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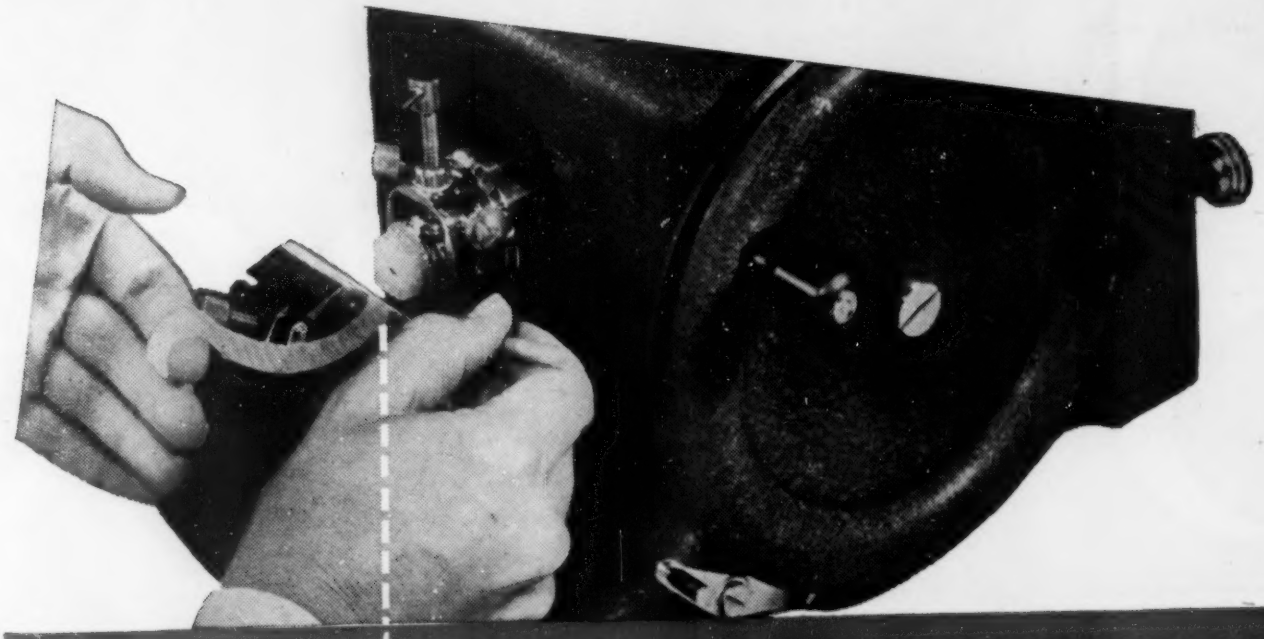
First International Poliomyelitis Conference

(See page 34)



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Bird Migration and the Concept of Continental Drift

Albert Wolfson
Northwestern University, Evanston, Illinois

THE ORIGIN AND EVOLUTION OF MIGRATION in birds has long been a favorite topic for theoretical discussion, but current theories, although numerous, fail to provide a satisfactory explanation for some of its fundamental features.

When a recent study of continental drift revealed some correlations with the routes of migration, the concept was studied still further in relation to the time of origin and distribution of birds and the evolution of migration.

This critical study and analysis have led to the conclusion that *continental drift was the stimulus for the evolution of the more highly developed forms of migration.* In essence, the hypothesis to be presented holds that the birds that responded to the movements of the continents as they drifted apart and moved northward, and/or followed the development of the new oceans created by drifting land masses, belong to those species which at the present time exhibit migration in its most highly developed form.

Since some knowledge of the problems of migration and the concept of drift are requisite for an evaluation of the arguments, a review of each is presented before elaborating the hypothesis.

The Problems of Bird Migration

The fundamental problems of bird migration, as formulated by Thomson (*8*), provide a convenient framework for a discussion of the present status of our knowledge. These problems are (1) the origin of migration, (2) the ends served by migration, (3) the annual stimuli for migration, and (4) the path and goal of flight.

The origin of migration. Current theories of the origin of migration are based on the assumption that migration as we know it today has resulted from the response of birds to a repetitive event in their racial history, with this induced response ultimately becoming hereditary.

With such a broad assumption, numerous theories can and have been postulated, differing in their selection of the factors responsible for initiating migration and in their speculation on the distribution of the stationary, ancestral stock. Two major patterns are evident in these theories.

According to one pattern, migratory birds originated in the Northern Hemisphere and were originally stationary. With the occurrence of a great climatic change as manifested, for example, by glaciation, they were forced southward. With the gradual retreat of the glaciers they returned northward to their ancestral home, only to be forced southward again with the approach of winter. Eventually the habit became inherent in the species.

The objections to such a theory are numerous and strong. It can be readily dismissed on the grounds that the birds that were forced southward were extinct long before the glaciers receded, if they had not been destroyed on their breeding grounds. Consequently, there would be no population with an urge to return to the ancestral "home."

A more refined form of this theory omits the idea of an urge to return to the ancestral breeding grounds, but postulates that as a result of glaciation there was a concentration of birds in tropical latitudes. Subsequently, the breeding range was extended northward as the ice receded.

According to the other pattern, birds originated in the Southern Hemisphere and spread into northern regions because of the competition for breeding places. At the close of the breeding season they returned to their ancestral home in the south. With the advent of spring, the stimulus for reproduction drove them northward again.

Modifications of this theory postulate causes other than reproduction and homing instinct as the stimuli for the original movements. Postbreeding wandering and search for food, for example, have been suggested as the causes for the northward movement, and adverse, seasonal, climatic conditions and search for food as the causes for the southward movement.

In general, theories of this type recognize the two important phases in the annual cycle of birds—the reproductive, or breeding, phase and the postbreeding, or winter feeding, phase—each with its own requirements. Such theories postulate further that originally one area sufficed for both phases, as it does today for many nonmigratory birds, but eventually two areas were occupied annually.

The migratory routes under these circumstances are supposed to have developed with the spread of the species into the new area. The birds of today, therefore, are believed to be following the path of great racial movements that took place in the distant past.

This second type of theory of the origin of migration is supported by much of our knowledge of the

behavior of birds and their response to environmental factors. It is, nevertheless, inadequate. It fails, for example, to account for the remarkable routes of migration over large bodies of water, for the great distances that separate the breeding and wintering areas of many species, and for the cessation of breeding in the southern, ancestral area; and it fails to explain how the movements involved in the "expansion" and "retreat" of the species—an acquired characteristic—became hereditary.

The ends served by migration. That migration serves useful ends in many cases has not been doubted, for without usefulness, it has been argued, it would not have survived. But what tends to confuse the issue is the reasoning that the ends served constitute the causes of migration. This type of reasoning, for example, is responsible for the widely held but unsubstantiated view that the reproductive "urge" is the stimulus for migration.

On the whole, investigations of the usefulness of migration have been concerned with discovering and defining the effects of seasonal environmental factors on the life of birds because of the obvious correlation of migration with such factors. The results of such investigations have led to the conclusion that the purpose of migration is to secure a favorable environment throughout the year.

The annual stimuli for migration. The problem of the annual stimuli for migration has received the most attention in recent years, and much has been contributed to our understanding of this aspect of migration. The success of the investigations can be attributed in large part to the use of the experimental method and physiological studies of resident and migrant individuals.

Rowan (*3*), who was the first to use the experimental approach, concluded that spring migration is a part of the breeding cycle and is induced by gonadal secretions. The fall migration, however, he found to be independent of the influence of the gonads (*4*). The external factor which induced the development of the gonads was proven to be increasing day lengths. This external stimulus would, therefore, apply only to those birds that wintered north of the equator.

Almost 10 years elapsed before a further experimental analysis of the problem was undertaken by Wolfson (*9*). The results of these experimental and physiological studies did not corroborate Rowan's conclusion on the role of the gonads in migration. Instead, the new facts, which stressed the total physiological condition of the bird, pointed to a maximum body weight, due to a heavy deposition of fat, as the diagnostic feature of a readiness to migrate. Its significance was further attested by the fact that nonmigratory races of the same species do not show such deposition of fat or marked seasonal variations in weight.

There is no doubt that the annual stimulus for migration arises from some physiological change which is induced by increasing day lengths of winter and spring. The fact that residents and migrants differ in their weight responses would seem to favor the view that a maximum body weight, and not the gonad, is involved in initiating migratory behavior.

Studies of the annual stimulus have contributed little toward the elucidation of such problems as the origin of migration and the path and goal of flight, but one is in a better position to speculate on the evolution of migration, for whatever theory is formulated, it must include some plausible explanation of the evolution of the annual stimuli which are operative today.

The path and goal of flight. This final problem has been under careful investigation since the introduction of banding and other marking techniques. Through the use of such techniques, as well as extensive field observations, the breeding and winter ranges and the path of flight between them are well known for many birds, especially those which breed in the central and northern parts of North America and Europe.

This knowledge has served to impress ornithologists still further with the extraordinary nature of migration, but, again, other fundamental problems have not been elucidated. Instead, new and perplexing ones have been added to an already enigmatic phenomenon.

How was one to explain, for example, the evolution of the amazing flight of the arctic terns (*Sterna paradisaea*) that breed in northern North America, then fly *eastward* across the Atlantic to Europe, and finally *southward* along the African coast to their winter home in the Antarctic region; or the flight of the Pacific golden plover (*Pluvialis dominica fulva*) which breeds in Alaska and adjacent portions of Siberia and either makes a nonstop flight across the Pacific to Hawaii or travels along the eastern coast of Asia as far south as Australia, New Zealand, and Tasmania? The routes of other birds and the distances flown are equally remarkable.

An explanation of these routes, it is generally agreed, can be found only in the history of the species.

The Concept of Continental Drift

The theory of continental drift, also known as the displacement hypothesis, includes all hypotheses postulating a large amount of horizontal movement of land masses and not merely the better-known conceptions of Taylor and Wegener.

Taylor, who was the first to present a definite and convincing hypothesis in 1908, was followed by Baker in 1911 and Wegener in 1912 (see *1* for review).

Wegener, because his ideas challenged more directly the recognized principles of geology and because of the various incongruities and inaccuracies in his works, was primarily responsible for provoking a strong reaction.

The outline of the concept presented here is taken from Du Toit and portrays in broad outlines the present status of our knowledge. The fundamental features of this concept follow.

(1) Two great land masses, a *northern* one, *Laurasia,* and a *southern* one, *Gondwana,* were present throughout the Paleozoic and most of the Mesozoic. These two major units were separated by a vast sea known as the Tethys. Its trend was generally east-west; its depth varied in space and time, and several times its shallowing at some points put Gondwana into connection with Laurasia for short periods. By the Tertiary it was reduced considerably.

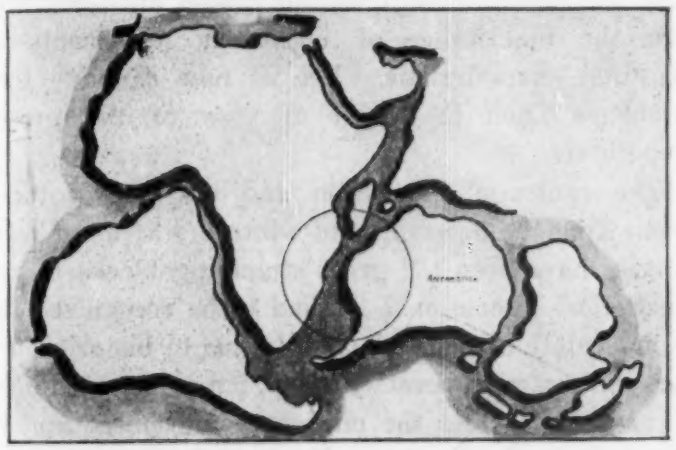

FIG. 1. Gondwana during the Paleozoic and early Mesozoic. The space between the various portions was then mostly land. (Redrawn from Du Toit, 1937. Based on Lambert's Equal Area Polar Projection.)

(2) During the Cretaceous these parent masses fragmented, and the resultant parts drifted.

(3) With reference to the land masses as we know them today, from Gondwana the following evolved: South America, Africa, Arabia, Madagascar, peninsular India, Australia, and Antarctica. From Laurasia evolved North America, Greenland, Europe, and Asia.

(4) To indicate how the fragmentation occurred and the movements of the fragments, attempts have been made to reassemble the parts.

Reassembly of the parts of Gondwana is illustrated in Fig. 1. It should be noted that the entire mass was located in the southern hemisphere. The drift of the parts, with the exception of Antarctica, was dominantly northward. At the same time, there was an eastward and westward drift, South America drifting *westward,* and Africa and the other fragments drifting *eastward.* The result of the fragmentation and drift of the parts was the creation of the *South Atlantic* and *Indian Oceans,* the original parts being eventually arranged about them in their present positions.

(5) Reassembly of the fragments of Laurasia is shown in Fig. 2. The fragments, it is noted, were not as widely dispersed as those of Gondwana, but the

FIG. 2. Laurasia during the early Mesozoic. The space between the various portions was partly land, partly sea. (Redrawn from Du Toit, 1937. Based on Lambert's Equal Area Polar Projection.)

same relative pattern of drift took place—namely, a northward, and an eastward and westward movement. North America moved ultimately *northwestward,* while Eurasia moved *northeastward.* The result of fragmentation and drift was the creation of the *North Atlantic* and *Arctic Oceans.* The southern part of the present North Atlantic was originally a small ocean (Poseidon), and it is generally accepted as the locus at which rifting started.

Greenland may be considered as a point of reference from which North America drifted farther westward and Eurasia, eastward. The broad region extending

FIG. 3. Reassembly of Gondwana and Laurasia to indicate the position of the equator during the Cretaceous. Stippled areas represent shallow seas of the Eocene. (Reconstructed from Wegener and Du Toit.)

from Portugal through Ireland to Scandinavia, which was land throughout the Triassic, represents the subsequently torn-off margin of North America.

During the Mesozoic, and before then, Laurasia lay *farther to the south,* with much of its southern margin reaching or *extending across the equator.* At Cretaceous time the equator is regarded as running through Central America, North Africa, Southern Europe, Persia, and Himalaya. Laurasia, then, since Cretaceous time has been displaced northward approximately 35° of latitude (Fig. 3).

(6) Laurasia and Gondwana are viewed as *separate* and, in certain respects, independent masses belonging to the Northern and Southern Hemispheres. Although the fragments of both show the same drift pattern, their displacements have not been equal or simultaneous.

(7) The rate of movement in drifting is considered as being extremely slow at all times.

Migration in Relation to Drift

In past theoretical discussions it has been assumed that migration arose in stationary populations because of the "separation" of originally coincidental or adjoining nesting and feeding areas. The result of the separation was the origin of *short,* periodic flights such as are known in many tropical species today.

This assumption has been generally accepted to explain the *origin* of migration, but it has never been adequate to explain the *evolution* of migration.

The evolution of migration according to the present hypothesis is envisaged as follows:

(a) Before the advent of continental drift many birds were performing short flights between breeding and feeding areas.

(b) With the onset of drift these areas diverged slowly.

(c) The birds continued their use of these areas because of their well-developed homing instincts.

(d) As the distances increased, only those individuals that had the necessary sources of energy for the flight survived.

A number of important facts are in agreement with the above postulates.

Birds originated in the Jurassic, the period preceding the Cretaceous, and by the end of the Cretaceous modern types of birds were well represented. It is conceivable, therefore, that birds were well established and that migratory movements had originated *before* the advent of drift.

Homing instincts are known in diverse groups of animals, but in no other group is it as well developed and of such general occurrence as it is in birds. This behavior of returning to a known territory or "home" has been shown to apply not only to the nesting area but also to the feeding area in the winter range. Unquestionably, it forms the foundation for all types of migratory movements.

As the nesting and feeding areas diverged, one can conceive of the birds making the trip successfully only if they had the necessary sources of energy for the flight. Only those individuals that had suitable hereditary variations in this direction would have survived as the distance became greater. Inevitably, natural selection would have resulted in the survival of a population that developed sufficient energy reserves at the proper season. Recent studies have demonstrated the correlation between the onset of migration and a heavy deposition of fat, and there can be no doubt that such fat provides the energy for the migratory flight.

In the earlier discussion it was pointed out that current theories were inadequate because they failed to account for the remarkable routes of migration over large bodies of water, the great distances separating the breeding and wintering areas of many species, the cessation of breeding in the ancestral area, and the inheritance of migratory movements—an acquired characteristic. Let us now examine these problems from the point of view of the present hypothesis.

The routes of migration and the vast distances separating the breeding and wintering areas of many species have been the great stumbling blocks in past theoretical discussions. It had to be recognized that their evolution was undoubtedly due to historical factors that are not operative today, but what was difficult to accept was that the migratory movement and the route that eventually evolved had survival value. This difficulty arises from the fact that many birds fly much greater distances and subject themselves to more rigorous conditions than seems necessary to find suitable breeding or wintering grounds.

When we examine some of the remarkable routes of migration and the vast distances between breeding and wintering areas, and *think of them as evolving in response to drifting continents,* what heretofore has been enigmatic becomes explicable.

The migratory species that perform the longest flights and, hence, demonstrate the development of migratory behavior in its highest form are those belonging to the group known as the shore birds. Consequently, it is from this group that a number of the following examples have been chosen.

(1) Three species that have as great a migratory range as any others known are the turnstone (*Arenaria interpres*), the sanderling (*Crocethia alba*), and the knot (*Calidris canutus*).

The turnstone is almost cosmopolitan in range, nesting in the far north to 70° latitude and probably farther. It migrates throughout the world, mainly along salt waters, and its wintering range extends as far as South Africa, Australia, New Zealand, and

Chile. The sanderling covers a similar vast area, nesting in the Arctic regions and wintering as far south as Patagonia, South Africa, and Australia. The knot, which is circumpolar in its summer range in the Northern Hemisphere, winters in the Southern Hemisphere as far south as the Cape of Good Hope, India, Australia, New Zealand, and Patagonia. The proximity of these winter ranges in the reassembly of Gondwana is striking!

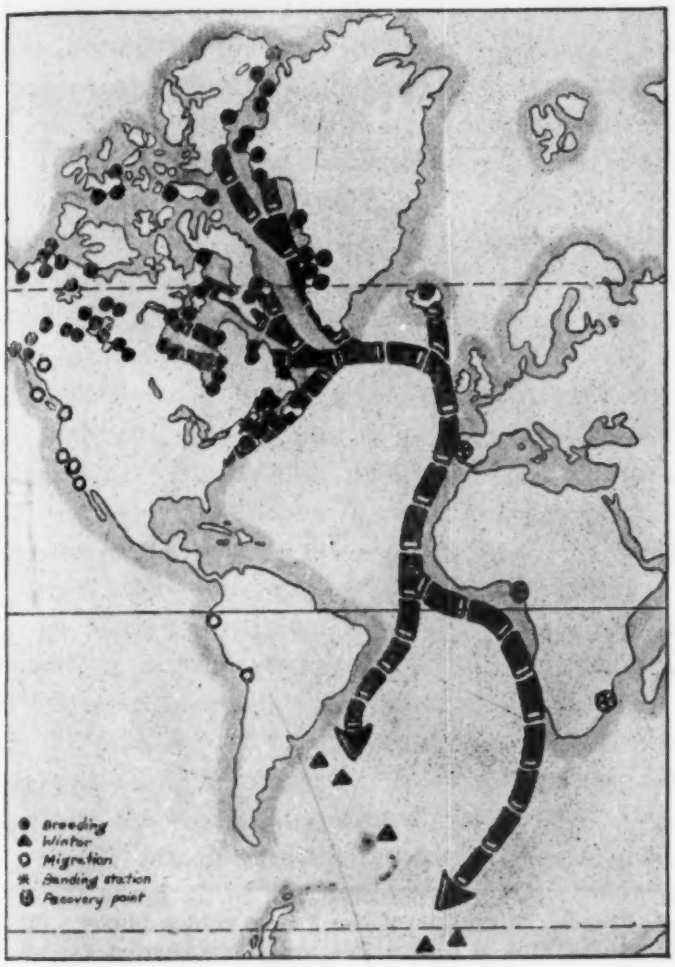

FIG. 4. Migration and distribution of the arctic tern of eastern North America. Recovery records are based on banded individuals. (From Lincoln, 1935, with modifications.)

In terms of the permanence of the continental masses and ocean basins it is difficult to explain these widespread distributions and migrations. However, in terms of an original Gondwana and Laurasia, their subsequent fragmentation and northward drifting, these distributions are readily explained.

Gondwana may be thought of as the original site of an extensive population that eventually spread into Laurasia, breeding as far as its northern margin, but returning to its ancestral site to feed. As Gondwana fragmented, *each part was still retained as a division of the wintering range* and, hence, the present widely scattered wintering area. The extreme northern breeding ground can be accounted for by the northward displacement of Laurasia and its eventual fragmentation to form much of the Arctic Ocean around which these species breed.

(2) The species that performs the longest flight among all birds is the arctic tern. It breeds in the circumpolar region of the Northern Hemisphere as far north as 82° latitude and in winter ranges from the tropical Atlantic to Antarctic Oceans as far south as 66° latitude. A distance of about 10,000 miles separates the extremes of its breeding and wintering areas.

As with the species mentioned above, the *extent* of migration is readily explicable in terms of continental drift, but what is more remarkable is the correlation between drift and the *path of flight*.

In North America this species breeds as far south as Great Slave Lake, in the interior of Canada, and on the Atlantic coast as far as Massachusetts. It also breeds commonly on the west coast of Greenland and in Iceland. When the fall migration begins, these birds do not fly southward, as one might expect, but fly *eastward* across the North Atlantic to the shores of Europe, and *then southward* along the

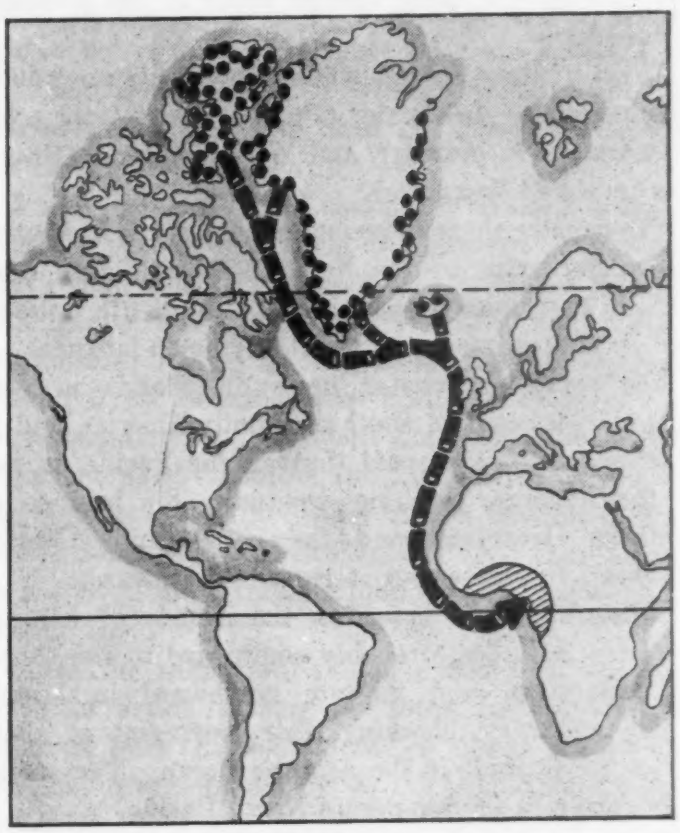

Fig. 5. Migration of the Greenland wheatear. Breeding and wintering areas are diagrammatically represented by dots and diagonal lines, respectively.

African coast to their wintering area in the South Atlantic and Antarctic regions. Some individuals may cross to the eastern coast of South America south of the Azores and then continue southward (Fig. 4).

Is it merely coincidence that the direction of flight is in accord with the pattern of drift? If so, how, then, can one explain the east-west flight across the North Atlantic and the vast distance between the breeding and wintering grounds?

According to drift, the present wintering area would represent that part of the South Atlantic pro-

duced by the drifting of the Gondwana fragments. The flight across the North Atlantic would represent the east-west drift of the parts of Laurasia. Thus, the route seems to be the natural consequence of drift, the birds following their breeding grounds as they drifted westward.

Other species also perform this east-west flight across the North Atlantic, and among these the flight of the Greenland wheatear (*Oenanthe oenanthe leucorhoa*) is worth noting. This species breeds regularly in Ellesmere Island, Greenland, and Iceland. After the breeding season it flies eastward, migrates through the British Isles and France, ultimately reaching West Africa, where it spends the winter (Fig. 5). Again, there can be no question of the coincidence of the pattern of drift and the route of migration.

(3) There are other species which also seem to have followed the development of the Atlantic Ocean according to drift, but instead of breeding in the Northern Hemisphere, these species breed in the Southern Hemisphere.

Three of these species whose movements are known are the greater shearwater (*Puffinus gravis*), the sooty shearwater (*P. griseus*), and Wilson's petrel (*Oceanites oceanicus oceanicus*).

The greater shearwater moves northward in May on the western side of the North Atlantic Ocean from Tristan da Cunha in the middle of the South Atlantic and by August ranges to about 60° north latitude.

The sooty shearwater nests on islands in New Zealand seas and in southern South America and in May migrates northward through the Pacific as well as the Atlantic, reaching eventually the latitude of southern Greenland and the Kuril, and Aleutian Islands. In September it returns southward.

Wilson's petrels breed on the islands of extreme southern latitudes, probably southward to the shores of Antarctica, and migrate northward in March, April, and May, checking their movement at about 50° north latitude in the Atlantic Ocean. They occur only rarely in the temperate North Pacific.

The fact that these species migrate so far northward *after* the breeding season is readily explicable in terms of drift and the hypothesis presented.

(4) Another remarkable route of migration which has defied explanation is that from Arctic regions to the islands of the South Seas, extending in some cases to the eastern atolls of Polynesia. A number of species perform this flight regularly, some of them, such as the Pacific godwit (*Limosa lapponica baueri*), reaching as far south as New Zealand.

The Pacific golden plover, one of the better-known species which uses this route, nests along the Bering Sea Coast of Alaska and in northeastern Siberia. After the breeding season the species travels south along the eastern coast of Asia as far as Australia, Tasmania, and New Zealand, and through the Pacific Islands from Hawaii southward. The individuals which reach Hawaii are believed to fly nonstop from Bering Strait, thereby covering a distance of about 2,800 miles over the open sea and without landmarks (Fig. 6).

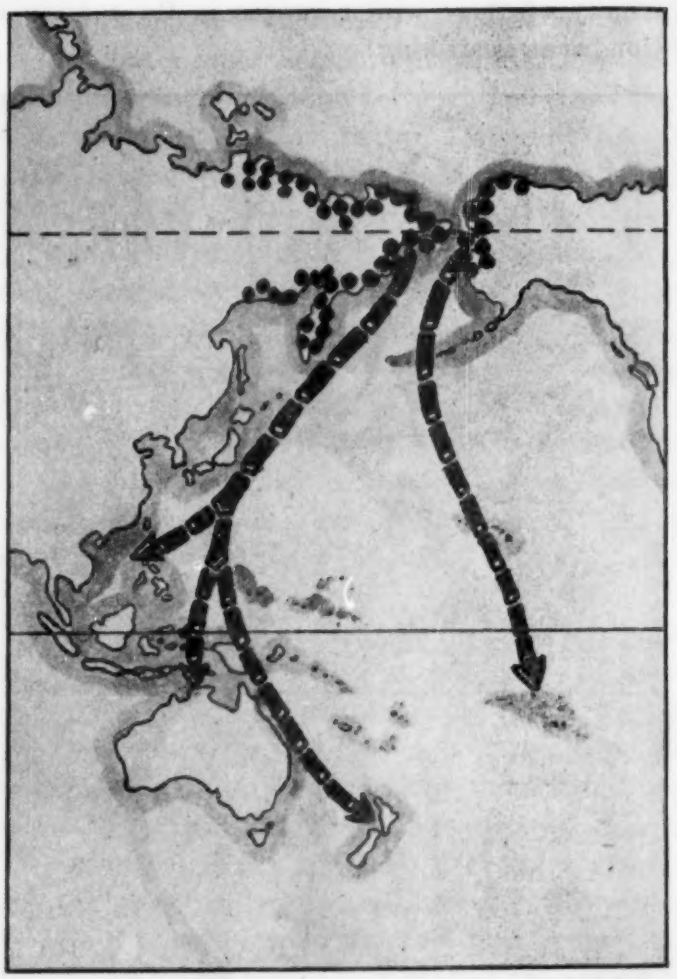

FIG. 6. Migration of the Pacific golden plover. The breeding area is diagrammatically represented by dots, with the more western portions omitted.

How can one explain the evolution of such routes from the viewpoint of permanent ocean basins and continents? According to drift, the path of migration becomes explicable, even though some of the details may be obscure.

Before drift occurred, Laurasia lay far to the south of its present position, an estimated 35°–45° of latitude. This displacement southward would alone decrease considerably the distance between the Pacific Islands and northeastern Siberia and Alaska. Taking into account some meridianal drift, the amount and direction of which is difficult to estimate, the present wintering and breeding grounds were conceivably much closer together at one time. The evolution of the route of migration could then have occurred *gradually* as Asia and North America drifted northward.

In addition to these specific routes, two other general features pertaining to the direction and extent of migration are readily explicable in terms of drift and,

conversely, support the hypothesis presented. These features are: (a) the general trend of migratory routes in North America and Eurasia, and (b) the extensive development of migration as a *northward* movement.

When one compares the general trend of migration in North America and Eurasia, some rather fundamental differences come to light. In North America the general trend of many migratory routes in the spring is from the *southeast* to the *northwest,* and in a few instances there are marked westward flights along some routes. In Eurasia the general trend in the spring is from the *southwest* to the *northeast,* and many species fly directly eastward for a part of their route.

Is this agreement between the general trend of many migratory routes and the resultant directions in which North America and Eurasia were drifting merely coincidental?

One of the most puzzling facts about migratory behavior which previous theories have not accounted for is that migration is essentially a *northward* movement, irrespective of how far south a species may winter. Whereas many species that winter in the temperate latitudes of South America and Africa migrate to the Northern Hemisphere to breed, *few species* that "winter" in northern temperate latitudes migrate into the Southern Hemisphere to breed.

If migration developed because of range expansion from tropical and subtropical breeding grounds, why did it not develop equally toward both poles? Again, is it merely coincidental that extensive migrations are northward and all of the continental masses (with the exception of Antarctica) drifted *northward* since the Cretaceous?

It must be pointed out that migration does occur among species that breed in the Tropics and Southern Hemisphere, but in most instances these are comparatively short flights, and in only a few cases do these birds cross the equator. These flights from southern temperate latitudes, it should be noted also, are northward and coincide in some cases with the northward flight of those migrants that will fly to the Northern Hemisphere to breed.

In considering the next problem, the cessation of breeding in the ancestral area, the question arises, first, as to whether the present breeding grounds represent the *ancestral* range or the *acquired* range. Implicit in the present hypothesis is an *origin in the Southern Hemisphere* for those migrants that winter there today. That these migrants breed now in the Northern Hemisphere is explained by the effect of day length on the breeding cycle of birds.

As the birds crossed the equator it is held that their breeding cycle was altered so that eventually they bred only in the Northern Hemisphere. Since birds normally have only one breeding cycle a year, the cessation of breeding in the ancestral area would have resulted.

Supporting this contention is experimental evidence of the effect of changes in day length on the breeding cycle; the fact that populations of the same species breed at opposite times of the year when their breeding grounds extend to both sides of the equator; and the fact that some species, when transported from the Southern Hemisphere, where they normally occur, to the Northern Hemisphere, show a reversal of their breeding cycle to conform with the seasons of the Northern Hemisphere.

If it is true that migratory individuals developed within stationary populations that originated in the Southern Hemisphere, as this hypothesis maintains, then it follows that surviving nonmigratory populations of the original stationary stock should be located in the southern part of the range. An examination of a large number of cases substantiates this conclusion, and it is evident in such cases that migratory behavior has been an important isolating factor in speciation.

This conclusion would also apply in those instances where a species originated in northern land masses that were formerly connected, and we would expect to find insular areas, particularly with a highly mixed avifauna in regard to migration. This is especially true of Great Britain, where a number of species are represented by both resident and migration populations. Some of the migrants winter there, while others breed there. It is interesting to note that the migrant populations that breed in England come from Ireland in the west and France, Spain, and Portugal in the south.

Since the migration of the arctic tern has been given in detail, it may be noted further that the antarctic tern (*Sterna vittata*), a closely related species that breeds primarily on the islands in the Antarctic Ocean, is comparatively nonmigratory and has evolved into several subspecies because of its strong "attachment" for particular islands as nesting grounds.

The final problem of the inheritance of an acquired characteristic does not exist under the present hypothesis. Migration *originated* in those groups that had an *inherent pattern of behavior* of regular, short flights to and from the breeding area. It *developed* to a great extent in those groups (a) that responded to drifting of continental masses, (b) that had the hereditary pattern to provide for the energy sources needed in migration, and (c) that had the physiological mechanism to correlate the occurrence of these resources with suitable seasons for migration and breeding.

Summary and Discussion

The present hypothesis for the evolution of migration is founded on three premises: (1) that the inherent behavior of moving to and from nesting and feeding grounds had appeared soon after the origin of birds; (2) that many birds returned to the same feeding and nesting areas even though they became divergent; and (3) that only those individuals survived as migrants that developed the necessary sources of energy to enable them to complete the flight between the diverging areas.

It is postulated that the cause of the divergence was the drifting of continental masses and the concomitant development of oceans.

That such drifting played an important role in the evolution of migration seems attested by the extent, direction, and general pattern of migration and the correlation of these features with the evolution of the continental masses, temporally and spatially.

That the establishment of energy resources played an important role in the evolution of migration is attested by the occurrence of periodic fat deposition in migrants, its absence in closely related resident forms, and the correlation of fat deposition and migratory behavior under natural as well as experimental conditions.

Various causes for the *original movements* may be postulated, but whatever the cause of these movements —and there is no reason to believe that it was identical in all migratory species—the salient feature, the gradual divergence and northward drifting of land masses, would still provide the stimulus for the evolution of extensive migratory flights.

Migratory behavior, according to the hypothesis presented, did not evolve into its highly developed forms because it served useful ends, but was the natural consequence of an inherent behavior pattern responding to the drifting of continental masses. The "adaptive features" of migration, such as leaving an area with the approach of winter, are, therefore, the *result* of natural selection and *not the cause* of migration as implied in previous discussions of the ends served by migration.

Although Pleistocene glaciation has been emphasized in the past to explain the origin and evolution of migration, it seems rather that it was only a *modifying* factor. It is beyond the scope of the present paper to discuss its role, but one point is relevant.

Although the glaciers would obviously have claimed the breeding and feeding areas of many species, many of the shore birds and other aquatic species would not have been affected. They still could have bred at the edge of the glaciers as they do in Greenland and Antarctica today. This observation, plus the evolution of migration according to drift, would account for the fact that migration in its most highly developed form occurs commonly among the shore birds and other aquatic species that feed in marine waters.

Other investigators, who have been primarily concerned with the origin, dispersal, and evolution of particular faunas, such as birds (*2*), mammals (*7*), amphibians and reptiles (*6*), and fishes (*5*), have found that it is not necessary to invoke drift to interpret their data. While that may be true, by *not* considering drift they are left with a number of significant problems which have necessitated, in some cases, the postulation of some rather extraordinary concepts.

Having examined these problems and concepts, I believe that a re-examination and re-evaluation of the pertinent zoological facts in relation to drift will show that drift is not only logically equivalent to current explanations based on permanence, but, *at the same time,* it provides solutions for the enigmatic problems that result from the point of view of permanence.

It is recognized that the reception afforded the hypothesis presented will be considered by some to rest in no small measure on the fate of the concept of continental drift. There are many biologists who believe that the establishment of the validity of drift must come first from the geologist before they can consider it in relation to their problems of evolution and distribution. On the other hand, if biologists have an adequate knowledge of the properties, requirements, and behavior of organisms and have confidence in that knowledge, they can make a substantial contribution to our knowledge of the earth's history. Thus, that birds migrate along the routes indicated and show certain distributional patterns seems to me to constitute prima-facie evidence for the drifting of continental masses.

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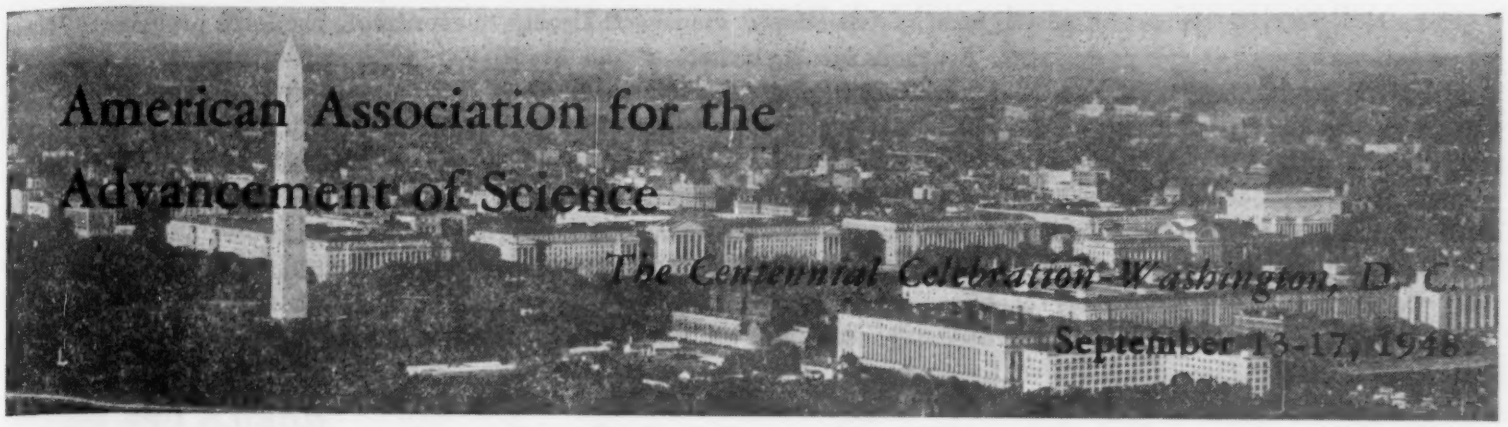

Centennial Membership Goal—15,000 New Members in 1948

Since mid-January 7,000 new members have joined the Association, and with the continued vigorous campaigning of the AAAS local membership committees the objective set by the Centennial Policy Committee—15,000 new members in 1948—will be successfully attained.

Approximately 104 committees have been organized locally throughout this country, Canada, and Hawaii, and their productive activities are daily giving impetus to the membership campaign. Some indication of the enthusiastic response among members of the Association is reflected in the following extracts from letters of local committee chairmen:

Philip H. Cinis, secretary of the local committee in Springfield, Massachusetts, reports that his group plans to arrange a program to coincide with the Centennial Celebration in Washington, and then to continue as a permanent group with bi-monthly meetings at which members and their guests will meet and deliver papers on their work. Other officers of this progressive group are I. Jacques Yetwin, chairman; R. K. Mueller, vice-chairman; D. S. Pollard, treasurer; and W. W. Williams, program committee chairman.

Paul G. Roofe, chairman of the local committee at the University of Kansas, states that all science teachers have volunteered to canvass their classes for membership, that a AAAS radio script is being prepared for local broadcast, and that feature articles are in the making for local papers. Dr. Roofe's committee is also planning an "All University Science Convocation."

R. A. Fennel, chairman of the Michigan State College group, states in a progress report on the work of his committee that Chester F. Lawson, a member of the M.S.C. group, has informed all department heads as to the objectives and work of the Association and that they in turn will promote its purposes among students and colleagues. The technical employees of the Reo Motor Company and the Olds Motor Company are being screened for invitations, and Dr. Fennel's committee has nominated for membership the staff members of the Michigan State Department of Health and Michigan State College.

E. W. Bird and his committee on the campus of Iowa State College are proceeding to acquaint nonmembers with some of the advantages of belonging to the Association. A recent letter from the committee to all staff members of the college is quoted below in its entirety.

> Several of us who are members of the American Association for the Advancement of Science have been asked to acquaint those of you who are not members of the Association with the organization, its aims and purposes. The Association formed in 1848 will celebrate its hundredth anniversary this year and an effort is being made at this time to solicit you as a possible member of the AAAS.
>
> Membership in the Association is open to individuals in the fields of pure and applied science, the social sciences and engineering. Individuals who are members of the staff, but whose interests in these fields are those of the layman, are, likewise, asked to join us since one of the society's objectives is a wide-spread dissemination of scientific information to all intelligent individuals.
>
> The current membership of the Association is approximately 40,000. Some of the great names to be found in the Association's rosters are Joseph Henry, Louis Agassiz, Simon Newcomb, Asa Gray, William H. Welch, T. C. Chamberlin, A. A. Michelson, Charles W. Elliot. Locally there are 126 members of the Association.
>
> The objectives of the Association are "to further the work of scientists, to facilitate cooperation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress."
>
> In order to facilitate these objectives, the Association issues two publications, *Science* and *The Scientific Monthly*. You will find these publications thoroughly modern and in keeping with the times. Copies of these publications have been made available in the lower lobby of the library through the kindness of Mr. Robert Orr. These, together with other information relative to the Association, will be on display during the week of June 6.
>
> We of the committee urge you to join us in membership. Will those of you who are interested, kindly so signify to E. W. Bird, 200 Dairy Industry Building, by June 18, so that we may recommend you for membership to the national organization. We of the committee urge you to contact any of us if you desire further personalized information relative to the Association.

From time to time the action of the local membership committees will be reported in *Science*. All those serving on these committees are volunteers, who have indicated a desire to help promote the objectives of the Association by participating in the membership drive. The value of the personal approach to stimulate interest in the Association cannot be overestimated, and in large communities several committees are independently soliciting new members in order to cover effectively each campaign area. When three or more committees have been organized in one locality, the chairmen are asked to meet and elect an area chairman to coordinate the local program. Members of the Association who wish to take an active part in this worth-while endeavor to increase the AAAS membership—15,000 new members in 1948—may secure the name and address of their local committee chairman by writing to the Washington office of the Association.

Now available for the use of members only are special Centennial Membership Application Forms to be used for the personal solicitation of members among friends and colleagues. These forms will be furnished promptly upon request.

NEWS and Notes

W. V. Lambert has resigned as administrator of the Agricultural Research Administration, USDA, to become dean of the School of Agriculture and director of the Experiment Station at the University of Nebraska. He will take up his new duties October 1. Other departmental changes recently announced include the appointments of **Frank H. Spencer**, assistant chief, Bureau of Entomology and Plant Quarantine, as the assistant administrator of the Agricultural Research Administration, and **Edmund Stephens** as the new assistant chief of the Bureau.

Roger Revelle, who was in charge of the oceanographic section in the Bikini atomic bomb tests, has been named associate director of the Scripps Institution of Oceanography of the University of California. Dr. Revelle is an authority on marine sediments.

Clayton M. Zieman has been appointed assistant professor of physics at Wabash College, effective in September.

Samuel Goldich, of the Texas Bureau of Economic Geology and the U. S. Geological Survey, has been made associate professor of petrography and petrology in the Department of Geology at the University of Minnesota, effective September 15. Dr. Goldich succeeds **F. F. Grout**, who has recently retired.

Hubert O. Jenkins has been appointed professor of biological sciences at the newly formed Sacramento (California) State College. For the past 17 years he has been associated with the Sacramento Junior College.

Francis W. Stengle, Technical Services Division, Chemical Corps Technical Command, Army Chemical Center, Maryland, formerly curator of the Chemical Warfare Materiel Museum, is now serving as technical editor with the Editorial Branch of the Division.

Lowell Besley, professor of forest management, West Virginia University, has resigned to become head of the Department of Forestry at the University of British Columbia, Vancouver.

John Field, physiologist at Stanford University, will leave shortly for the Arctic Research Laboratory, Point Barrow, Alaska, to begin a study on the mechanisms by which small cold-blooded animals adapt themselves to climatic extremes of heat and cold. Working under a contract with the Office of Naval Research, Dr. Field will study related forms of life in Alaska, in the more temperate areas of the Pacific Coast, and in the tropical zone of Panama. **Clarence N. Peiss**, of Palo Alto, California, will serve as research assistant in the project, remaining at Point Barrow until next March.

Neil W. Stuart, plant physiologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, **C. J. Willard**, professor of agronomy at Ohio State University, and **J. L. Lush**, professor of animal genetics at Iowa State College, recently arrived in England for a 3-month survey of agricultural research while serving on the staff of the U. S. Mission on Science and Technology, which is surveying and evaluating research in Great Britain on medicine, public health, engineering, and agriculture.

James G. Retallack, of the University of California, Berkeley, and **Robert W. Thompson**, research associate at the Massachusetts Institute of Technology, have recently been appointed assistant professors of physics at Indiana University.

James Murray Luck, professor of biochemistry at Stanford University, represented the National Academy of Sciences at a conference on scientific information held last week by the Royal Society in London.

M. John Boyd, associate professor of biological chemistry in the College of Medicine, University of Cincinnati, will become professor of chemistry and head of the Hahnemann Medical College Division of Chemistry beginning September 1. His wife, **Marion Abbott Boyd**, plans to resign her present position as associate professor of hygiene at Cincinnati to accompany Dr. Boyd to Philadelphia.

Visitors to U. S.

Karl Frederich Bonhoeffer, formerly of the Kaiser-Wilhelm Institute, Berlin, has recently arrived to serve as the first Reilly Lecturer in Chemistry at the University of Notre Dame. He will lecture to the staff and graduate students throughout the summer session, ending August 13.

Ian W. Wark, chief of the Chemical Division of the Australian Council for Scientific and Industrial Research, expects to arrive from England the first

week in August. His work, which was published mainly in the United States, has been in the fields of surface chemistry and the theory of the flotation process. Until October, when he returns to Australia, Dr. Wark may be reached through the Scientific Research Liaison Office of the Australian Embassy, 1785 Massachusetts Avenue, N.W., Washington, D. C.

Grants and Awards

The Royal Society has announced the election of one new fellow and four foreign members. They are, respectively, Sir Stafford Cripps, Member of Parliament; Detlev W. Bronk, foreign secretary of the National Academy of Sciences (U.S.A.), chairman of the National Research Council, and director of the Johnson Foundation, University of Pennsylvania; Luitzen E. Jan Brouwer, professor of mathematics in the University of Amsterdam; Maurice J. G. C. Caullery, professor in the Faculty of Biological Science, Paris University; and Linus C. Pauling, professor of chemistry at the California Institute of Technology.

The Medal for Merit has been given to 65 scientists and engineers of the wartime office of OSRD, in recognition of their outstanding services to the armed forces. Vannevar Bush presented the award to the 7 Washington, D. C., recipients of this honor: Leason Heberling Adams, John Swalm Burlew, and Richard Brooke Roberts, all of the Carnegie Institution of Washington; Roger Sherman Warner, Jr., and Carroll Louis Wilson, of the U. S. Atomic Energy Commission; Edward F. Knipling, Bureau of Entomology, U. S. Department of Agriculture; and Alan Tower Waterman, of the Office of Naval Research.

Other recipients of the Medal for Merit include: Roger Adams, Department of Chemistry, University of Illinois; Homer B. Adkins, Department of Chemistry, University of Wisconsin; Henry Butler Allen, Franklin Institute; Luis Walter Alvarez, Department of Physics, University of California; Bennett Archambault, M. W. Kellogg Company; James Gilbert Baker, Harvard College Observatory; Edward Lindley Bowles; John Ely Buchard and Samuel Hawks Caldwell, of the Massachusetts Institute of Technology; Harris Marshall Chadwell, Rockefeller Foundation; Robert D. Coghill, Abbott Laboratories; Edwin J. Cohn, Harvard University; Ralph Alexander Connor, University of Pennsylvania; Alphonse R. Dochez, Columbia University; Lee Alvin DuBridge, California Institute of Technology; Melville Eastham, General Radio Company; Alexander Ellett, Zenith Radio Corporation; Raymond Henry Ewell, California Research Institute; Horace Sayford Ford, Massachusetts Institute of Technology; William Alfred Fowler, California Institute of Technology; Ivan Alexander Getting, Massachusetts Institute of Technology; Lars Olai Grondahl, Union Switch and Signal Company; Paul Magnus Gross, Duke University; Albert B. Hastings, Harvard University; Clarence N. Hickman, Bell Telephone Laboratories; Hoyt C. Hottel, Massachusetts Institute of Technology; Frederick Lawson Hovde, Purdue University; Walter Samuel Hunter, Brown University; Herbert Eugene Ives, Bell Telephone Laboratories; Zay Jeffries, General Electric Company; Charles S. Keefer, Boston University; Paul Ernest Klopsteg, Northwestern University; Irving Langmuir, General Electric Company; Warren Kendall Lewis, Massachusetts Institute of Technology; Alfred L. Loomis, Loomis Laboratories; Stanley Platt Lovell, Beckwith Manufacturing Company; Duncan Peck MacDougall; Max Mason, California Institute of Technology; Robert Raynolds McMath, University of Michigan; Edward Leyburn Moreland, Massachusetts Institute of Technology; William Albert Noyes, Jr., and Brian O'Brien, both of the University of Rochester; Linus Carl Pauling, California Institute of Technology; Isidor Isaac Rabi, Columbia University; Harold Bours Richmond, General Radio Company; Louis Nicot Ridenour, University of Illinois; Hartley Rowe, United Fruit Company; Bruce Hornbrook Sage, California Institute of Technology; James A. Shannon, E. R. Squibb and Sons; Thomas K. Sherwood, Massachusetts Institute of Technology; Homer W. Smith, College of Medicine, New York University; Earl P. Stevenson, Arthur D. Little, Inc.; Irvin Stewart, University of West Virginia; Chauncey Guy Suits, General Electric Company; Frederick Emmons Terman, Stanford University; Warren Weaver, Rockefeller Foundation; Clyde E. Williams, Battelle Memorial Institute; and Edgar Bright Wilson, Jr., of Harvard University.

The American College of Physicians will provide a limited number of fellowships in medicine from July 1, 1949 to June 30, 1950. Carrying stipends of from $2,200 to $3,200, the fellowships will provide an opportunity for research training either in the basic medical sciences or their applications to clinical investigation. They are designed to benefit physicians in the early stages of their preparation for a teaching and investigative career in internal medicine. Assurance must be given that the applicant will be acceptable in the laboratory or clinic of his choice, and that he will be provided with the necessary research facilities.

Application forms may be secured from The American College of Physicians, 4200 Pine Street, Philadelphia 4, Pennsylvania, and must be submitted in duplicate not later than November 1, 1948.

Grants totaling over $2,632,000 for cancer research and related projects were recently announced by Oscar R. Ewing, Federal Security Administrator. The distribution of funds was recommended by the National Advisory Cancer Council, an independent board of six U. S. cancer authorities, which met at the National Cancer Institute June 8–9, and was approved by Leonard A. Scheele, surgeon-general of the U. S. Public Health Service.

Non-federal institutions received $919,310, the largest federal grant ever made for cancer research. These funds will support individual projects in over 50 hospitals, universities, and other institutions in the United States and in one foreign institution, the Biological Institute of the Carlsberg Foundation, Copenhagen. The largest single grants in this group went to the University of California Medical School, San Francisco, for a study of the physiology of patients with cancer and experimental chemotherapy of cancer; the National Research Council,

Washington, D. C., for correlation of structure with biological action of chemical compounds; the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, for a genetic investigation of cancer and abnormal growth; the Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York City, for steroid hormone research; and the University of Washington School of Medicine, Seattle, for serological studies in neoplastic growth, with special reference to the preparation of suitable antigens for complement-fixation tests.

Teaching grants amounting to $416,335 will be distributed among 18 medical schools and 5 dental schools. In the medical schools, the funds will be used to expand the arrangements for teaching diagnosis and treatment to undergraduates and, in the dental schools, the emphasis will be placed on the detection of oral cancer.

Nine cancer control projects have been allotted $162,073. The largest single grant in this category was made to the California Department of Public Health to establish a training center in the cytologic test for cancer at the University of California, to be under the direction of Herbert F. Traut and George N. Papanicolaou. A second grant was made to the same agency for conducting a cancer symposia for physicians in nonmetropolitan areas of California. Other recipients were: the American Pharmaceutical Association, Washington, D. C., for a cancer education program for registered pharmacists; the American College of Surgeons, Chicago, for a survey of cancer clinics; the Illinois State Department of Health, Chicago, for operation of a cancer mobile unit in the rural areas of Kentucky; the University of Minnesota, for a cancer detection center; the University of Nebraska Hospital (College of Medicine), Omaha, for improved service to cancer patients; the University of Utah, Salt Lake City, for a special cancer control project; and the Wyoming State Department of Public Health, Cheyenne, for tumor clinics and a detection center.

The three grants for aid in the construction of facilities for cancer research totalled $1,134,368. The largest of these went to Emory University, Atlanta, Georgia, for use in its projected Medical Research Building. The others were awarded to the University of Rochester, Rochester, New York, to provide a new wing on the School of Medicine and Dentistry, and the University of Texas-M. D. Anderson Hospital for Cancer Research, for the construction of a laboratory.

Colleges and Universities

The new Institute of Geophysics at the University of California, Los Angeles, sponsored its first annual conference in Berkeley in the latter part of May. Papers were presented on the program which allotted equal amounts of time to meteorology, oceanography, and earth physics. The featured address of the program was presented by J. Gilluly, professor of geology on the Los Angeles campus of the University, who discussed "Distribution of Mountain Building in Geologic Time."

The Institute has only recently begun to function. In addition to the director, Louis B. Slichter, the resident staff includes Robert E. Holzer, professor of geophysics and electric-storm specialist, who will be engaged in high atmosphere studies, and David T. Griggs, formerly of Harvard University and the U. S. Geological Survey, who will conduct research in earth physics. The first objective of the organization is fundamental research in the dynamics of the earth, and second, applied geophysics. The Institute hopes to stimulate and coordinate research in geophysical sciences on all of the campuses of the University. Besides the faculty members who serve the Institute on a part-time basis, the staff will this year include the following visiting professors: C. E. Palmer, tropical meteorologist from Australia; R. C. Stoneley, of Cambridge University, England, specialist in earthquake waves and tides; and Eric Palmén, meteorologist and oceanographer, of the University of Helsinki, Finland, and the University of Chicago.

A series of six lectures on radiations and radioactive substances in biology and medicine was opened July 7 at the University of Chicago by an address on "Significance of Radiosubstances and High Energy Radiations in Biology and Medicine," by Raymond E. Zirkle, of the Institute for Radiobiology and Biophysics. The lectures are open to the public and will be presented each Wednesday afternoon at 4:30 for six weeks in the University's Social Science Building. The five other address of the series are: July 14, "Effects of Radiation on the Cells of the Body," by William Bloom, professor of anatomy; July 21, "Effects of Radiation Exposure on Populations," by Robert D. Boche, assistant professor of zoology; July 28, "Care of Persons Exposed to Radiation," by J. Garrott Allen, assistant professor of medicine; August 4, "Techniques of Using Isotopes as Tracers," by Konrad Bloch, assistant professor of biochemistry; and August 11, "Uses of Radioactive Substance in the Treatment of Disease," by James W. J. Carpenter, assistant professor of roentgenology.

The University of New Hampshire has announced the following appointments to its Zoology Department: Lorus J. Milne, of the University of Vermont, associate professor; Margery J. Milne of the University of Vermont, assistant professor; M. Jean Allen, of Flora Stone Mather College, Western Reserve University, instructor; Wilbur L. Bullock, of the University of Illinois, instructor; John D. Ifft, of Simmons College, visiting lecturer in embryology during the summer term; Auley A. McAuley, of Michigan State University, visiting lecturer in zoology during the summer term; and George M. Moore, acting head of the Department for the past year, head of the Department.

Meetings and Elections

Final plans have been completed for the first International Poliomyelitis Conference, which begins in New York City next Monday. The officers and members of the Advisory Committee for the Conference are shown on this week's cover as they completed last-minute details. They are: (seated, *left to right*) Thomas M. Rivers, director, Hospital of the Rockefeller Institute for Medical Research; Hart E. Van Riper, medical director of the National Foundation for Infantile Paralysis, and Conference general chairman; Irvin Abell, clinical profes-

or emeritus of surgery, University of Louisville; Morris Fishbein, editor, *Journal of the American Medical Association*; and Frank R. Ober, professor emeritus of orthopedic surgery, Harvard University; (standing, *left to right*) Rustin McIntosh, professor of pediatrics, Columbia University; Kenneth F. Maxcy, professor of epidemiology, Johns Hopkins University; David P. C. Lloyd, associate member, the Rockefeller Institute for Medical Research; and Stanley E. Henwood, executive secretary.

The Northeastern Division of the American Phytopathological Society will meet at Ithaca and Geneva, New York, July 22–23. Those planning to attend are requested to communicate with L. J. Tyler, Department of Plant Pathology, Cornell University, Ithaca, New York, before July 18.

The Society of Systematic Zoologists was organized in Chicago on December 29, 1947, at a meeting attended by 66 systematists. Waldo L. Schmitt was elected president, and Richard Blackwelder, Alfred E. Emerson, E. Raymond Hall, C. F. W. Muesebeck, Orlando Park, Alfred S. Romer, and Hobart M. Smith, council members.

The objective of the new society is to promote the interests of taxonomy and systematic zoology. To carry out this objective it has been proposed that the society obtain a voice in national scientific circles; it exert its influence on taxonomic matters in national and international meetings; it sponsor discussion or study groups to increase interest in the fundamental aspects of taxonomy; it serve as a clearinghouse to obtain discussion, study, and support of projects of interest or importance to taxonomists; and it help bring taxonomists together for mutual benefit by issuing directories and news letters, encouraging the exchange of ideas, and holding an informal annual meeting for personal contact.

At present 286 charter members have been enrolled in the society. At the organizational meeting it was decided to enroll charter members until the time of the next meeting. Any one interested in systematic zoology is urged to request application blanks from the secretary, G. W. Wharton, Department of Zoology, Duke University, Durham, North Carolina.

The next meeting of the society will be held at 10:00 A.M., September 12, 1948, in Washington, D. C.

An International Congress of Mathematicians will be held in Cambridge, Massachusetts, in 1950 under the auspices of the American Mathematical Society. The Society originally planned to act as host for a Congress in September 1940, which was also scheduled to meet in Cambridge. At the 1936 Congress in Oslo, Norway, the invitation for the 1940 Congress was issued by the American delegation in the name of the American Mathematical Society. Plans for this Congress were practically completed when the outbreak of World War II, in September 1939, made it necessary for the Society to postpone the Congress to a more favorable date. An Emergency Committee was established to carry on in the interim and, on recommendation of this Committee, the Council of the Society voted to hold the Congress in 1950.

The 1950 Congress will be the third International Congress of Mathematicians to be held on the continent of North America. The first was held at Northwestern University in 1893, and the second at the University of Toronto in 1924. International Congresses were held at intervals of approximately four years, except when war intervened, until 1936. There has been no international gathering of mathematicians since that time, and it is the sincere hope of the Organizing Committee that the gathering in 1950 will be a truly international one, that the American mathematicians will attend in large numbers, and that all other countries will be well represented. The Council of the American Mathematical Society has voted unanimously to hold a Congress which will be open to mathematicians of all national and geographical groups.

The dates for the Congress have been fixed as August 30–September 6, 1950. Harvard University will be the principal host institution. A number of other institutions in metropolitan Boston will join in the entertainment of visitors by arranging special features on their campuses.

In recent years mathematicians have been much impressed by the success of the conference method for presenting recent research in fields where vigorous advances have just been made or are in progress. In view of the success of mathematical conferences on special topics which have been held in Russia, France, Switzerland, and, more recently, at the Princeton Bicentennial Celebration, the 1950 Congress will include conferences in several fields. For the 1940 Congress, conferences in four fields had been planned. The number of conferences was thus restricted lest the introduction of a promising and novel feature result in failure through the dissipation of interest and energy. A subcommittee of the Organizing Committee, under the chairmanship of A. A. Albert, is now studying the question of the number and the fields of the conferences to be included in the 1950 Congress, and the results of the committee's deliberations will be reported at a later date.

Following the established custom, the Organizing Committee plans to have a number of invited hour addresses by outstanding mathematicians. In addition, sectional meetings for the presentation of contributed papers not included in conference programs will be held in the following fields: I, Algebra and Theory of Numbers; II, Analysis; III, Geometry and Topology; IV, Probability and Statistics, Actuarial Science, Economics; V, Mathematical Physics and Applied Mathematics; VI, Logic and Philosophy, History and Education.

The official languages of the Congress will be English, French, German, Italian, and Russian.

Plans for the Congress are under the supervision of an Organizing Committee which was elected by the Council of the American Mathematical Society in February 1948. The chairman is Garrett Birkhoff of Harvard University, and the vice-chairman is W. T. Martin of Massachusetts Institute of Technology. Other members of the Committee are: J. L. Doob, G. C. Evans, J. R. Kline, Solomon Lefschetz, Saunders MacLane, R. G. D. Richardson, J. L. Synge, Oswald Veblen, J. L. Walsh,

D. V. Widder, Norbert Wiener, and R. L. Wilder.

Many of the subventions promised for the 1940 Congress are still available. A Financial Committee under the chairmanship of John von Neumann is endeavoring to secure additional funds. Besides support from Harvard University and Massachusetts Institute of Technology, generous subventions have been subscribed for the Congress by the Carnegie Corporation, the Institute for Advanced Study, the National Research Council, and the Rockefeller Foundation.

An Editorial Committee under the chairmanship of Salomon Bochner will assume responsibility for publication of the *Proceedings*.

J. R. Kline, of the University of Pennsylvania, has been named secretary of the Congress and R. P. Boas, executive editor of *Mathematical Reviews*, has been designated associate secretary.

Harvard University has offered the use of its dormitories and dining rooms for mathematicians and their guests for the period of the Congress. The Organizing Committee hopes that it will be possible to furnish room and board without charge to all mathematicians from outside continental North America who are members of the Congress. Congress membership fees and rates for room and board will be announced well in advance of the opening of the Congress.

The Entertainment Committee, of which L. H. Loomis, of Harvard University, is chairman, is planning many interesting features, including a reception, garden party, symphony concert, and banquet. It is hoped that American mathematicians will be able to assist in the entertainment by putting their automobiles at the disposal of the Entertainment Committee for trips to be made out of Cambridge.

Every effort will be made to facilitate the travel at reasonable cost of foreign participants while in the United States. Previous to the Congress, opportunity will be given them to see New York City under the guidance of some mathematicians.

Detailed information will be sent in due course to individual members of the American Mathematical Society and to foreign mathematical societies and academies. Others interested in receiving information may file their names in the Office of the Society, and they will receive from time to time information regarding the program and arrangements.

Communications should be addressed to the American Mathematical Society, 531 West 116th Street, New York City 27, U.S.A.

Deaths

Joyce C. Stearns, former director of the Metallurgical Laboratory, Argonne National Laboratory, and dean of faculties at Washington University, died June 11 in St. Louis, Missouri.

François E. Matthes, 74, former member of the U. S. Geological Survey and one of its authorities on glaciers, died June 21 in Berkeley, California.

A. Felix du Pont, 69, director and former vice-president of E. I. du Pont de Nemours & Company, died June 29 in Rehoboth Beach, Delaware.

James M. Godfrey, 67, professor emeritus of anesthesia at Hahnemann Medical College, died June 30 at Buck Hill Falls, Pennsylvania.

Arthur Mullin Wright, 68, former chairman of the Department of Surgery, New York University College of Medicine, died of a heart attack as he was addressing the University Club in New York City.

Taliaferro Clark, 81, retired assistant surgeon-general of the U. S. Public Health Service died July 3, in New York City.

Richard Strong, 76, professor emeritus of tropical medicine at Harvard Medical School, died July 4 in Boston, Massachusetts. Dr. Strong was credited with the discovery of tick transmission of disease germs and viruses.

An archeological study of the Canadian Arctic Archipelago will be conducted this summer by Henry B. Collins, Jr., of the Smithsonian Institution, and his assistant, Colin Thacker, of the National Museum of Canada. The headquarters for the expedition will be on Cornwallis Island, where a joint Canadian and U. S. meteorological station has recently been established. Until the airstrip was constructed at the station, the region under investigation, lying mostly above the 75th parallel, was essentially inaccessible for research of this kind. The area concerned will be the Parry and Sverdrup Islands groups, upon which numerous exploration parties have reported old village sites and ruins of houses constructed of stone and whalebone. This type of house is characteristic of the Thule culture of the prehistoric Canadian and Greenland Eskimo, which is thought to be an outgrowth of the earliest Eskimo culture of the Bering Sea region. Dr. Collins believes it most likely that the Eskimo migrations eastward to Greenland passed over the Parry and Sverdrup Islands, and, among the things he hopes to discover in this study, is the rate of such migrations.

The Max Planck Society for Advancement of Science, a new German scientific society honoring the memory of the late Max Planck has recently been formed, according to *Chemical and Engineering News*. The new society, replacing the disbanded Kaiser-Wilhelm Institute and headed by Otto Hahn, Nobel Prize winner, hopes to instill new spirit into German scientists engaged in fundamental research.

The British Department of Scientific and Industrial Research has announced the organization of the Interdepartmental Committee on Overseas Scientific Relations to consider and advise on questions of United Kingdom Government policy regarding overseas scientific relations. The committee, headed by Sir Edward Appleton, will include representatives of government departments, the foreign secretary of the Royal Society, representatives of the British Council and of the Conference of Research Associations, and 2 university scientists. Communications should be addressed to the secretary: Mr. H. L. Verry, Overseas Liaison Division, Department of Scientific and Industrial Research, 142 Piccadilly, London, W. 1, England.

Comments and Communications

A Revised Proposal for Errors and Emendations in the Rules of Zoological Nomenclature

Suggestions for changes in Articles 19 and 20 of the International Rules, dealing with the formation and spelling of scientific names, was published in *Science* (October 3, 1947, pp. 315–316) by a subcommittee of the Smithsonian Institution Committee on Zoological Nomenclature.

Comments sent in by readers have resulted in reconsideration of many points and in reorganization of the proposal in order to eliminate ambiguities and clarify points which had been misunderstood. The revised version is presented as the formal proposal of the Smithsonian Committee. It has been sent to the International Commission in the form of a suggested amendment to the Rules, in order that the Commission might begin consideration of it at the Paris Congress.

Taxonomists are urged to write direct to the Commission, stating their views on these questions either with reference to this proposal or not.

As before, the wording of these proposals has been very carefully studied. Unless otherwise defined, the words must be taken literally in their customary sense and be interpreted strictly. It may be well to emphasize that Article 19 (Revised) deals with the problem of deciding on the spelling of new names *before* their proposal; Article 20.I. (Revised), with the spelling of a name as first published and the possibility of making subsequent changes in the spelling; and Article 20.II. (Revised), with subsequent spelling variations as such. The two articles have been reversed in position and number because of the obvious inherent sequence from formation through original publication to subsequent reuse.

Names using numerals (*2-punctatus, 16-maculata*) or letter symbols (S-*scriptus*, M-*litterus*) may be held to be invalid under the present Rules, and the subcommittee is inclined to this view. However, the existence in the literature of certain groups of animals of a very considerable number of these names, including many that date from the 10th edition of Linné, seems to make it impracticable to rule them out. We therefore suggest special provision for them as an exception to the general rule that only Latin characters may be used.

Formation and Orthography of Zoological Names

Article 19

In forming new names, only Latin letters are to be used, regardless of the characters used in quoting the source from which the name is derived. The Latin letters in this sense are those of the classical Latin alphabet and the Neo-Latin k, j, and w.

The use of diacritic marks (such as ö, ñ, ø, č, and å) in forming names is optional, regardless of use in the source as quoted.

Recommendation: It is strongly recommended that, in forming new names, any diacritic marks be omitted or replaced by standard substitute letters (such as ue for the Germanic ü and aa for the Scandinavian å), as the use of diacritic marks by subsequent workers may be impracticable because of differences in type fonts.

Example. If an author desires to dedicate a genus to the Swedish scientist, Stål, and a species to the Czech scientist, Kříž, he should employ such simple forms as *Stalia* (or *Staalia*) and *krizi*. The forms *Stâlia* and *křiži* are not recommended but are not to be rejected on this account.

Example. A name dedicated to Müller may be written *Mulleria, Muelleria,* or *Mülleria* at the author's choice or as circumstances dictate. (Note: This requires that Article 35,a and Opinion 147,1,a be amended to include words differing only in the use of ue and u, aa and a, or diacritic marks.

Names may be formed with a numerical prefix. The prefix should be the combining form of the Latin word for the cardinal number, written in Latin letters, but if written with an Arabic numeral, the name is not to be rejected on that account.

Example. A ten-spotted animal may be named *X-us decim-maculatus.* The use of *X-us 10-maculatus* is permissible but not recommended.

The use of a symbol prefix to show the shape of a marking or structure is not recommended, but, if the symbol is in the form of a Latin letter, such names are not to be rejected.

Example. Letter symbols such as V-*nigrum*, X-*maculatus*, and *C-luteum* are permissible, but ⊥-*signatus*, ∞-*maculata*, ⸮-*notata*, and Δ-*album* are not acceptable and have no status under the code.

Article 20

(I) The original orthography of a name is to be preserved unless it can be demonstrated in the original publication itself that there has occurred an inadvertent error, such as a lapsus or a copyist's or printer's error. The following are not to be construed as errors: incorrect transliteration, misuse of connective letters, and differences between the source and the name resulting from the application of Article 19. [See Opinions 8, 26, 36, 60, and 70.]

(a) When demonstrable in the original publication, such inadvertent errors in original spelling are correctable and are to be treated as if corrected wherever they occur; the corrected spellings are justified emendations and take the place of the original (erroneous) spellings in all respects, including date and authorship. The erroneous spellings have no separate status in nomenclature, do not preoccupy, are not available as replacement names, and never acquire validity by citation in synonymy. [See Opinion 26.]

(b) If an original spelling is suspected or claimed to publication itself, the original spelling is not subject to be erroneous, but there is no proof of error in the original change, even by the original author. [See Opinion 34.]

(c) If, in the original publication of a name, two or more spellings are used, without compelling evidence as to which is in error, the spelling employed by the first subsequent writer is to be adopted.

(II) In subsequent publications variant spellings may occur either through intention or misadventure. For the purpose of this section emendations are defined as changes that are originally stated to be intentional, or are demonstrably so; errors are any changes that are not emendations, including those of doubtful status which cannot be demonstrated from the original publication to be emendations.

Subsequent variant spellings are:

(a) Emendations that are justified under Section I above (see Ia); or

(b) Emendations that are not justified under Section I above. Such emendations have status as separately validated names with their own date and author; they are junior objective synonyms of the name in its original form; they are available as replacement names; they preoccupy any later names of the same spellings; and their authors are those who proposed them as emendations. [See Opinions 34, 120, 125, and 148 (with supplementary note).]; or

(c) Errors, as defined above. These are correctable and are to be treated as if corrected wherever they occur. They have no separate status in nomenclature, do not preoccupy, are not available as replacement names, and never acquire validity by citation in synonymy. [See Opinion 29.]

Example. The generic name *Oxytelus* (Coleoptera) has been written erroneously as *Cxytelus, Otytelus, Orytelus, Oxitelus, Oxyletus, Oxyteles, Oxyteius, Oxytelius, Oxytellus, Oxeotelus, Oxytetus,* and *Oyxtelus.* These are all to be corrected and have no separate status.

Example. In 1833 Germar (*Rev. Entomol.*, 1, 175) published the name *Dictyophara* (Homoptera). Among the numerous variant spellings of this name that have occurred is the lapsus *Dictyonota* of de Seabra 1930 (*Arq. Secc. Biol. Par.*, 1, 347). This lapsus may have been caused by association with *Dictyonota* Curtis (Hemiptera), with which insect it could not have been confused. The error is to be corrected and has no separate status in nomenclature. Or,

(d) Omission or addition of diacritic marks or the substitution for them of standard letters. Wherever these occur, they are not to be treated either as errors or as emendations but as permissible variations. As in Article 19, elimination of diacritic marks is recommended. Or,

(e) Translation of a numerical prefix into an Arabic numeral, or conversely, writing out a number in Latin characters. These are permissible variations, and the two forms are in every way coordinate. Either form preoccupies the other as well.

Example. Sexmaculatus may be written *6-maculatus*; *16-punctatus* may be written *sedecempunctatus* or *sedecem-punctatus.*

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Why Some Crop Plants Yield More Than Others

Occasion for this note is a recent paper by Kiesselbac (*J. Amer. Soc. Agron.*, 1948, 40, 216–236), who show that corn agrotypes with starchy endosperms are great superior in yielding ability to those with sweet endosperms. He finds an explanation therefor in a hypothes to the effect that carbon accumulation by the plant is influenced inversely by a concentration of water-soluble polysaccharides within the vegetation organs; in varying degree these carbohydrates block the capacity for carbon accumulation and yield, the blocking being least in the starchy and greatest in the sweet types. Therefore, yield depends on the gene that determines whether the endosperm is to be starchy or sweet.

This hypothesis will not be disturbed here except to point out that there are differences in yielding abilities (quantities of plant life) in all the families of plants that have furnished agrotypes for man's use—Gramminae, Leguminae, Chenopodiae, etc. It is highly desirable that plant geneticists and plant breeders should have a universal indicator of quantity of plant life—one that would combine certainty with convenience.

TABLE 1

NITROGEN AND YIELDS OF SUGAR CANES

Variety of sugar cane	Lbs of dry substance/acre	% of N in dry substance	Lbs of N in the crop	Lbs of dry substance/lb of N
	I	II	III	IV
Newer varieties				
POJ 2878	66,284	0.285	189.0	350.8
POJ 2714	65,307	0.290	189.3	344.9
JOJ 36M	68,599	0.290	199.0	354.8
Averages of new group	66,730	0.288	192.0	350.1
Older varieties				
BH 10(12)	64,509	0.306	197.3	326.8
Cristalina	58,979	0.318	197.3	314.5
Bourbon	52,529	0.356	187.1	280.9
Averages of old group	58,672	0.327	190.8	307.4

Such a universal indicator is available and has been available for 20 years in the inverse yield-nitrogen law. This law, which pervades (so far as is yet known) the entire kingdom of plants that have roots in the soil, takes care of all cases, regardless of water-soluble or insoluble carbohydrates or other nonnitrogenous plant products. The inverse yield-nitrogen law is to the effect that the yields of all agrotypes, without any clearly proved exceptions to date, are inversely proportional to the percentage of nitrogen contained in their whole dry, above-ground substance. It is shown below how Kiesselbach's data conform to this law. But first, two classic examples

from agrobiologic literature may be cited to show what is meant.

In a field test (José Carreras G. *Agronomia* (Lima), No. 15; cf. Willcox. *J. Amer. Soc. Agron.*, 1939, 31, 38) to compare 6 sugar-cane agrotypes, the data in Table 1 were obtained. Referring to Table 1, it may be pointed out that, beginning at the bottom of column I and proceeding up, the yields of dry substance increase from a low of 52,529 to a high of 68,599 lbs/acre, while in column II the percentage of nitrogen in the dry substance increases downward from 0.285 to 0.356%. From column III it is to be seen that the quantities of nitrogen removed by these agrotypes from the soil are substantially constant, notwithstanding the large differences in yield. (This constancy of nitrogen uptake is a highly interesting circumstance.)

TABLE 2

NITROGEN AND YIELDS OF SUGAR BEETS

Beet varieties	Yield of roots/acre	% of N in the beets	Lbs of N in the crop	Lbs of roots/lb of N
Wohanka ZR	33,690	0.172	57.74	583
Selecta	34,374	0.170	57.43	578
Unnamed	35,885	0.164	57.77	621
Kapotil	35,911	0.161	57.81	621
Dobrovice	37,035	0.153	56.66	653

The same picture is presented in Table 2, which reports (Pazler. *Z. Zuckerind. Czech. Republik*, 1932–33, 241) data of a comparison of 5 sugar-beet agrotypes. (The data in this case refer to the fresh beet roots.) Starting at the top of column I in Table 2 and going down, the yield increases from 33,690 to 37,035 lbs/acre, while in column II the nitrogen content decreases from 0.172 to 0.153%. From column III of this table the important

TABLE 3

NITROGEN AND YIELDS OF CORN AGROTYPES

Kind of corn planted	Lbs of dry substance/acre	% of N in dry substance	Lbs of N in the crop	Lbs of dry substance/lb of N
Dent	6,702	1.470	67.99	98.5
Sweet	4,191	1.541	64.68	64.7
Sweet	3,810	1.583	63.16	60.3

observation is again made that the amounts of nitrogen removed from the soil by these agrotypes are substantially constant, regardless of the differences of yield.

Kiesselbach's work was on the effect of outcrossing corn agrotypes having starchy and sweet endosperms, respectively. His data, recalculated to conform with Tables 1 and 2 above, are shown in Table 3 (his Table 5).

The inverse yield-nitrogen law is here plainly in action, as it seems to be everywhere else in the world of agrotypes. Whether one agrotype will yield more than another when both are offered the same agrobiologically normal conditions can be settled by determining their respective nitrogen contents; the one with the least nitrogen percentage will yield the most, regardless of botanical taxonomic position and regardless of genes that may control secondary characters.

One of the results of the writer's studies on the inverse yield-nitrogen law is the observation (mentioned above) that when agrotypes are grown under the same conditions in the same healthy soil, they take up substantially the same quantities of nitrogen without regard to the yield of nonnitrogenous plant substance. There are some apparent but no real contradictions of this principle which will not be discussed here. The full effect of the principle is not directly evident from the three above tables, which relate to crops grown on soils that were less than perfertile in three widely separated localities—Peru, Czechoslovakia, and Nebraska. In the writer's works it is shown that in the limit—that is, when the limit imposed by the law of diminishing increments of yield is reached and the agrotypes are giving their perultimate yields on perfertile soils, they all take up the same *maximum* quantity of nitrogen, which has been determined to be of the order of 318 lbs from one acre.

That is to say, in the limit, and within a narrow range of uncertainty which cannot be discussed here, all agrotypes of whatever description have the same quantitatively and stoichiometrically identical nitrogenous base; yet, with the same endowment of nitrogen out of which to fabricate their protoplasm and their enzymes, they differ enormously in ability to yield nonnitrogenous substance. The agrobiologic explanation of this is discussed elsewhere (*Quantitative agrobiology*, in three parts; Pt. 1: *The power of plants for growth and yield* is nearly completed).

In the work referred to, the writer uses the inverse yield-nitrogen law to tabulate the principal food-producing agrotypes according to their limit yielding abilities on one acre in one growth cycle. At the bottom of this scale are leguminous agrotypes like a soybean, with an average nitrogen content of 2.34% and an ultimate capacity for producing 13,531 lbs of dry substance/acre. Presently at the top of the scale is the gramminous POJ 2878 with 0.285% of nitrogen and a limit capacity for producing 111,578 lbs of dry vegetable substance/acre. The latter agrotype has 8.2 times more catalytic energy for photosynthesis than the former. In view of such spreads of yield as are indicated by this range of nitrogen percentage, it appears somewhat singular that plant geneticists and plant breeders have for so long overlooked the precision of the inverse yield-nitrogen law as a guide in the great work of extending the productivity of crop plants.

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TECHNICAL PAPERS

Prolonged Hypnotic States With "Local Signs" Induced in Guinea Pigs

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Studies of animal hypnosis in connection with research on conditioning and experimental neuroses have been carried out sporadically since the original work of Pavlov, particularly by his former associates (*1*). Indeed, animal hypnosis offers possibilities to study abnormal behavior, especially if the hypnotic drive is submitted to conflict with other conditioned or instinctive reactions. These possibilities have not been fully explored because of the brevity, complexity, and lability of hypnotic states in laboratory mammals. We succeeded in developing a prolonged hypnosis in guinea pigs by using a very simple procedure. This procedure also permits one to induce an hypnotic drive with a definite "local sign," thus offering new opportunities for research in the fields of neurophysiology and experimental psychology. The procedure, as well as our initial findings, are summarized below.

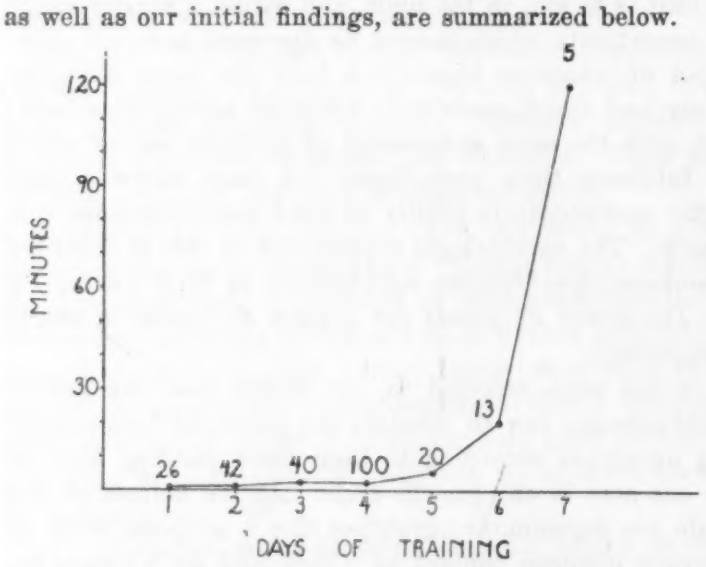

FIG. 1. This graph, which illustrates the initial phase of the "training" period of one guinea pig, shows maximum durations of hypnotic states during 7 days "training." The figures above the dots represent the number of trials for the corresponding day.

Each animal is put on its back to produce a spontaneous hypnotic state. The usual duration of this state is from a few seconds to a few minutes in adult guinea pigs. It can be discontinued by visual, auditory, or tactile stimulation. After the animal rights itself, it is immediately put back in a dorsal position, and this procedure is continued for about 2 hrs daily. Fig. 1 shows an example of such "training." The maximum duration of the hypnotic state during the first session for this animal was 35 sec, whereas on the 7th day it remained in the same state for 2 hrs without interruption. In this state the animal usually shows the following reactions: exophthalmos, eye-balls deviated downward and forward, paws extended and, at least at the beginning of the experiment, presenting a fine tremor.

The acquired aptitude for prolonged hypnotic state may be fixated for a considerable time. Thus, several animals did not present any change in their hypnotic reaction after 3 months free of any "training."

There are individual differences among guinea pigs. These concern both the facility with which prolonged hypnotic states are produced and the position in which hypnosis is most readily induced. Thus, animals which show a relatively long initial spontaneous hypnotic state exhibit the longest reaction after training. On the other hand, some animals are easier to train in a lateral than in a dorsal position. The latter, however, should be tried during the first sessions, as very few animals will remain in the lateral position at the beginning of experimentation. In animals difficult to train, it may be helpful to frustrate the righting attempts by stretching the whole body despite antagonistic muscle activity, associating this procedure with repeated sensory stimulation.

The animals which were put on only one side during their "training" period present prolonged reactions only

FIG. 2. *Left*: An animal presenting an hypnotic state when put on the right side. It remains in this state despite the clapping of the hands. *Right*: Another animal, after a prolonged training period, has become very submissive to the point of maintaining this uncomfortable position for an extended period of time despite sensory stimuli.

or preferentially on this side. Thus, there are animals in the laboratory which will lie on the right side for hours, presenting a typical hypnotic reaction, and only for a few seconds on the left side. In other animals the left side is preferential. Generally the eye signs are unilateral in such animals, or at least predominate on the side contralateral to the one upon which the animal is lying. Blinking occurs less often on this side. In some animals a unilateral exophthalmos persists even between experiments.

One of the most prominent signs of successful training is the relative ineffectiveness of stimulation. Thus, al-

hough the most intense auditory, visual, or tactile stimuli ay produce a motor reaction in an animal during a rolonged hypnotic state, these stimuli no longer cause he animal to right itself (Fig. 2, left). Sometimes the uinea pig makes a prolonged attempt to right itself y exhibiting disorganized rhythmic movements of the xtremities. He may succeed only in displacing his body n the table as if he were submitted to an antagonistic rive to "stick" to the supporting surface.

There is a functional gradation in the intensity of timulation necessary to discontinue a prolonged hypnotic tate. Thus, the appearance of another guinea pig in he visual field is more effective than an artificial visual timulus. A slight noise made by the opening of the age door may be more effective than a loud auditory timulus. However, frustration of righting attempts in he presence of the most potent stimuli decreases their ffectiveness. A well-trained, hungry animal may remain n a prolonged hypnotic state for hours, even though he s surrounded by a great amount of food.

In an animal trained in a lateral hypnogenic position, timuli may be more effective on one side than on the ther. For example, in an animal showing left lateral reference, visual stimuli applied to the left eye are more ffective.

Changes in the general behavior of trained animals are ifficult to appraise, as even normal guinea pigs, when atigued or frightened, often show prolonged periods of mmobilization. However, some trained animals may particularly easily present the hypnotic state in an upright osition. Thus, these animals may show characteristic xophthalmos in a sitting position and may remain undisturbed by stimuli when put in an upright position, their forelegs supported by a stand (Fig. 2, right). There s a decrease in spontaneous motor activity in the trained nimals. Furthermore, these animals are more often found in a prone position in their cages than the control nimals. However, the total appraisal of changes in eneral behavior requires more prolonged studies.

Reference

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Anoxic Survival and Diisopropyl Fluorophosphate (DFP)

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Heymans (*2*) has found that the use of diisopropyl luorophosphate (DFP) prolongs the survival period of medullary centers subjected to a complete arrest of circuation. Should this increased resistance to anoxia observed in the isolated head also apply to the intact rganism, then DFP might be valuable in minimizing the ffects of anoxia.

We have performed a series of experiments in an ttempt to apply Heymans' observation under a variety f conditions. Fifteen male rats were injected subcutaneously with 1.5–2.0 mg of DFP/kg, and 15 uninjected animals were subjected to the hypoxia produced by the inhalation of 3.9% O_2 in 96.1% N_2. The mean survival time of the DFP-injected rats was 14.78 ± 2.28[1] min. The controls' survival period was significantly longer, the mean being 23.41 ± 2.87 min. Thus, DFP, instead of conferring protection, apparently produces the opposite result. In this and subsequent experiments the dosage of DFP was not great enough to produce lethal effects in the time of observation. The observed mortality cannot be attributed to DFP toxicity.

Next, the duration of the survival period of the decapitated head of newborn rats was determined, the gasping of the head being taken as the criterion of the length of survival. Two mg of DFP/kg was injected subcutaneously into newborn rats 15–50 min. before decapitation. The 19 controls continued gasping for an average of 19.9 min. The heads of the 19 DFP-injected rats gasped for 19.0 min.—not a significant difference.

The influence of DFP on lethality caused by excessive doses of pentobarbital revealed that the average survival time for 7 control rats was 12.7 min, while 3 rats injected subcutaneously with 1.5 mg of DFP/kg 15 min. before receiving pentobarbital survived 4.3 min. The shortest period in any of the controls was longer than the longest period of survival in any of the injected rats.

Two rabbits, one of which had previously received an injection of 0.3 mg of DFP/kg in a carotid artery, were subjected to the inhalation of 3.9% oxygen in nitrogen. The control animal survived 37.5 min; the injected, 26.5 The control animal survived 37.5 min; the injected, 26.5.

TABLE 1

INFLUENCE OF DFP (1–2 mg/kg SUBCUTANEOUSLY) ON MORPHINE LETHALITY

Morphine dose (mg/gm)	Controls		DFP injected	
	No.	No. surviving 24 hrs	No.	No. surviving 24 hrs
.2512	6	4	9	9
.3981	20	8	23	15
.5012	14	0	14	3
.6000	10	1	10	3

Only with morphine did we have a suggestion of a possible beneficial effect. Thirty-one mice receiving 0.8–1.0 mg/gm of morphine sulfate intraperitoneally survived 14.31 ± 1.60 min, while 26 animals exposed to 2.0–3.0 mg of DFP/kg subcutaneously in addition to the morphine exhibited a mean duration of survival of 17.89 ± 2.32 min. The difference between the means is not statistically significant.

With smaller doses of morphine some of the animals survived more than 24 hrs, at which time the experiment was terminated (see Table 1).

Although the data in Table 1 show an apparent protection in the DFP-injected animals, when the LD_{50} was calculated by the method of Bliss (*1*), the values were 0.3237 ± 0.0388 mg/gm for the controls and 0.4472 ± 0.0258 mg/gm for the DFP-injected animals. On statis-

[1] Standard error of the mean.

tical analysis by the *t* test, the difference might be imputed to chance variation.

In Heymans' experiments the action of DFP on the brain was isolated from that of other portions of the body. A similar isolation of the influence of DFP could be achieved only in the experiments on the decapitated heads of newborn rats. The respiratory centers, however, are sensitive to morphine and pentobarbital.

Thus, under the conditions of these experiments DFP did not increase the survival time in acute anoxia, hypoxia, or following pentobarbital and morphine administration.

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2. Heymans, C. *Abstr. Communications XVII int. physiol. Congr., Oxford*, 1947, 152.

The Importance of the Time Element in Feeding of Growing Rats: Experiments With Delayed Supplementation of Protein

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University of Southern California Medical School,
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Recent reports from two laboratories (*1*, *3*) indicate that simultaneous feeding of all the essential amino acids is necessary to obtain maximum growth in animals (cf. *5*). As an extension of these studies, it seemed desirable to investigate the general importance of the time factor in feeding with respect to the synthesis of new body substance of infantile rats.

A survey of the literature reveals that the significance of the time factors in nutrition was recognized as early as 1937 by Larsen and Chaikoff, who demonstrated that the degree of N sparing in adult dogs "effected by a single feeding of carbohydrate was related to the time that elapsed between the consumption of the daily meal and the ingestion of the extra carbohydrate." Cuthbertson, McCutcheon, and Munro (*2*) confirmed these results for the adult rat and the adult human subject. However, they reported that, in contrast to the adult animals, the metabolism in the infantile rat was unaffected by the separation in the time of ingestion of the protein and carbohydrate moieties of the diet. Analysis of their data reveals that the growth rates of the animals in the experiments bearing on this point were all abnormally low, suggesting that some general deficiency in the food mixture used may have been the limiting factor in determining the growth rates.

We therefore decided to reinvestigate the problem, using diets which have proved adequate for the promotion of growth of young rats in earlier experiments.

[1] With the technical assistance of Miss Gloria E. Lusk.

Three distinct diets were prepared with the follow composition:

Diet A (protein free): corn starch, 3,050 gm (78.3% rice bran concentrate, 400 gm (10.26%); cotton oil, 200 gm (5.13%); U. S. P. salt mixture, 200 (5.13%); fish oil (1 gm contains 2,000 I.U. vitamin and 400 I.U. vitamin D), 50 gm (1.27%); riboflav 75 mg; Ca pantothenate, 150 mg; and choline chlori 2.5 gm.

Diet B (protein fraction): 50% washed casein a 50% fish proteins.

Diet C (combination): 80% Diet A and 20% Diet

Two groups of 6 male litter-mate Sprague-Daw rats were used in these experiments. The experimen group was fed Diet A from 4: 00 P.M. until 7: 30 A of the next day. The quantity of food consumed each rat was determined, and between 11: 00 A.M. a 1: 00 P.M. sufficient quantities of Diet B were fed give a total combined diet during the day with 2 protein. During the next day, the control animals w given an amount of Diet C equal to the total of diets consumed by their corresponding animals on mixed diet. The controls were permitted 80% of th

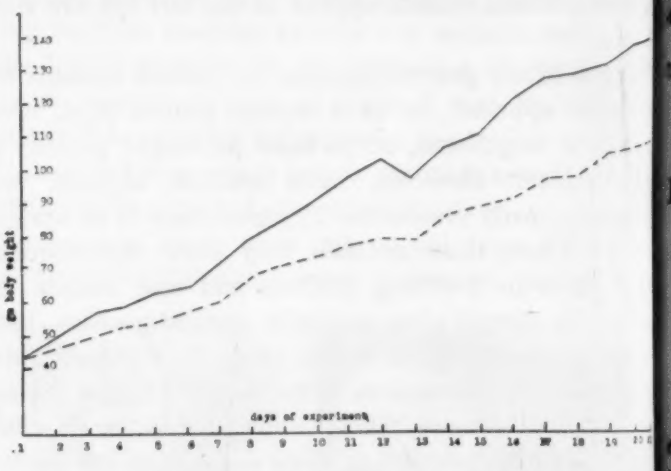

Fig. 1. Average growth curve of rats: ——— o mixed diet; – – – on delayed supplementation of protei

total ration from 4: 00 P.M. until 7: 30 A.M. and 2 from 11: 00 A.M. to 1: 00 P.M. Weights on all a mals were determined daily.

The experimental animals fed the separate diets fai to grow at a rate comparable to the control gro Within each group the weight curves were remarka uniform, so that the results are presented in Fig. 1 the average curves for the two groups.

During the 21-day period of the experiment, the c trol animals showed an average weight gain of 95 g while the experimental animals showed a gain of c 62 gm during the same period. The difference in effectiveness of the diet when fed in toto as compa to the divided feeding may be judged from the val for the ratio: total consumed feed in grams/gain body weight in grams. For the control animals ratio becomes 2.6 ± 0.23, while in the experimental a mals with the divided feedings the value is 3.7 ± 0.29 g

Experiments with adult rats with protein depleti showed that the weight increase during the period protein restoration was retarded if the protein and

ther food constituents were fed at separate times. These results in general confirm the findings of Larsen and Chaikoff and of Cuthbertson, McCutcheon, and Munro under somewhat different experimental conditions.

The experiments described above prove that, like the nitrogen equilibrium of the adult rat, the growth rate of the infantile rat is affected by separation in the time of feeding of protein from the feeding of the remainder of the diet. Our experiments throw no light on the possible mechanism of growth retardation by the temporal separation of feeding constituents of the diet. We plan to investigate whether simultaneous feeding of carbohydrates, fats, vitamins, or salts with the protein is necessary in order to achieve optimal growth. These experiments may help to clarify the contradiction between our results and those obtained by Cuthbertson, *et al.*

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Formaldehyde as a Mutagen in *Drosophila*

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Rapoport (*1*) reported that a high lethal mutation rate, chemically induced by the use of formaldehyde, was obtained in *Drosophila melanogaster*. He transferred 48-hr larvae and eggs of wild type *Drosophila* from "standard food" to food containing a water solution of formaldehyde "at sub-lethal concentrations." Directly after emergence, males from these formaldehyde cultures were tested for lethal mutations by the CLB method. The treated flies showed a mutation rate of 5.92% (47 lethals among 794 cultures). Among his 833 control cultures, only 1 lethal, or 0.12%, was recorded.

The work herein reported confirms Rapoport's findings. The food medium used contained cornmeal, molasses, agar-agar, and water and was enriched with a yeast extract. Formalin was added to the test medium after it had cooled, but was still the consistency which permitted the complete mixing of the formalin throughout the medium. The percentage of formalin added was determined using the water content of the medium as the point of reference and was expressed as per cent of formaldehyde. It is not known, however, whether or not the effective concentration of formaldehyde present in the medium was the same as that added to it originally, as some volatilization is certain to have taken place.

It was found that no eclosions were obtained from a medium containing more than 0.25% formaldehyde. Consequently, this may be said to be the highest "sub-lethal concentration" that was used.

Eggs from 1 to 4 hrs old were collected on agar blocks and permitted to hatch out and develop for an additional 48 hrs. Following this period the larvae were transferred to formaldehyde-containing medium. Table 1 gives data on the number of adults obtained in experiments with different concentrations of formaldehyde. Eclosions in untreated controls were close to 100%. It will be noted that a greater percentage of eclosions was obtained from 0.10% and 0.15% formaldehyde than from the two higher concentrations.

TABLE 1

Percentage of Eclosions Obtained With Four Different Concentrations of Formaldehyde

Concentration of formaldehyde (%)	No. of larvae	Percentage of eclosions
0.10	131	70.2
0.15	119	89.9
0.20	122	56.6
0.25	90	53.3

The Muller-5 method of detecting lethals in the X chromosome was used. The newly-hatched formaldehyde-treated males were crossed to Muller-5 females, and the daughters of these matings were individually crossed to Muller-5 males. All flies were raised at 25° C.

A lethal mutation was indicated as having occurred when there were more than four males in the culture, none of which possessed the wild type eye. Progeny tests were run from cultures that contained four or less males, all with the Muller-5 type eye.

Table 2 gives the number and percentage of lethal mutations obtained.

TABLE 2

Number and Percentage of Lethal Mutations

Formaldehyde (%)	No. of cultures	No. of lethals	Lethals (%)
0.10	713	46	6.45
0.15	644	29	4.50
0.20	441	27	6.12
0.25	212	12	5.66
Total treated	2010	114	5.66
Controls* ..	505	1	0.20

* Two doubtful cases not included. (Less than four Muller-5 males obtained from progeny tests.)

There is a very significant difference in the percentage of lethals obtained by the use of formaldehyde and the percentage obtained in the control animals. Moreover, the 5.66% herein obtained is very close to the 5.92% reported by Rapoport. The data presented here do not show a correlation between the concentration of formaldehyde and the induced rate of mutation. More extensive data and tests for the occurrence of lethal clusters will be needed to elucidate this question.

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Metabolism of Small Mammals, With Remarks on the Lower Limit of Mammalian Size

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It has long been realized that small mammals have a faster rate of metabolism than large ones, and the nature of this relationship for mammals between 20 gm and 3,600 kg has been studied by Benedict (*1*) and others. Recent observations have extended the weight range to include one of the smallest mammals, a 3½-gm shrew (*4*, *5*). Data presented in this report fill the considerable gap between this tiny mammal and the much larger mice and permit delineation of the shape of the critical lighter end of the curve for weight vs. metabolism.

Rate of metabolism was determined by measuring oxygen consumption in a closed-chamber apparatus similar to that described by Morrison (*3*) but with larger surface of soda lime than in the original apparatus. As in the preceding work (*5*), no attempt was made to determine what conditions were "basal" for each species: all the animals were tested at about 24° C and were not post-absorptive. Each test lasted at least 2 hrs, until one or more periods of complete repose had been recorded. All the specimens were adults.

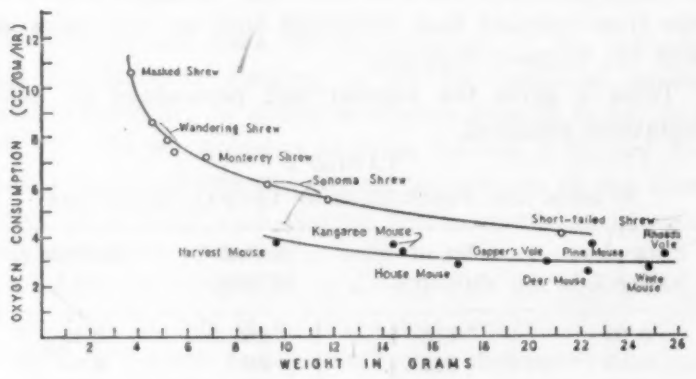

FIG. 1

In Fig. 1 the points for the short-tailed shrew (*Blarina brevicauda*), the masked shrew (*Sorex cinereus*), and the mice heavier than 15 gm are taken from Pearson (*5*) and in all instances are averages of several tests. Each measurement in Table 1 is the lowest metabolic rate recorded on a single test of each of the individuals listed.

It is apparent from Fig. 1 that in this weight range a resting shrew consumes oxygen more rapidly than a mouse of the same size. Presumably the cells of shrews metabolize at a faster rate than those of mice. However, it cannot be assumed that this is caused by a difference in body temperature, for the limited information available does not indicate that shrews have a higher temperature than mice (*2*, *6*).

Also revealed by Fig. 1 is the rather abrupt upswing of the curve at the lower end of the weight range. Instead of approaching infinity at 0 weight, the extrapolated curve for shrews becomes asymptotic at about 2.5 gm. This characteristic at once suggests why no adult mamm weighs less than 2.5 gm. A mammal smaller than th would be unable to gather enough food to support i infinitely rapid metabolism and would have to resort to lowered body temperature or some other fundament method of conserving energy. The young of ma mammals and birds, of course, are much smaller than th critical size, but the low body temperature of these ti offspring keeps their rate of metabolism slow enough that the parents can satisfy their food requirement Associated with this low body temperature is a sparsene of fur or feathers on the young of small species of bir and mammals. This nakedness may be a necessary co dition for keeping body temperatures lower than that brooding adults.

TABLE 1

RATE OF OXYGEN CONSUMPTION OF RESTING MICE AND SHREWS AT 24° C

	Common name	Weight (gm)	Oxygen consumption (cc/gm/hr)
Sorex vagrans vagrans	Wandering shrew	4.5	8.6
Sorex vagrans vagrans	" "	5.1	7.9
Sorex vagrans vagrans	" "	5.4	7.4
Sorex trowbridgii montereyensis ♂	Monterey shrew	6.7	7.2
Sorex pacificus sonomae ♂	Sonoma shrew	9.2	6.1
Sorex pacificus sonomae ♀	" "	11.7	5.5
Reithrodontomys megalotis longicaudus (average of 4 males)	California harvest mouse	9.6	3.8
Microdipodops megacephalus nasutus ♂	Kangaroo mouse	14.4	3.7
Microdipodops megacephalus nasutus ♂	" "	14.8	3.4

Since there are no mice in the weight range of th lightest shrews, the nature of the lighter end of th mammalian weight vs. metabolism curve must remai represented only by shrews. Some bats approach th small shrews in weight, but the lability of bat temperatur makes difficult a comparison between them and mor homeothermic animals. Apparently because of small si and strenuous activities, many bats have resorted to metabolic parsimony of periodically lowered body tem perature that allows their expensively gathered fuel t nourish them longer.

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IN THE LABORATORY

Constriction of the Mid-Thorax as a Means of Reflex Maintenance of Respiration During Barbiturate Narcosis

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Respiratory center depression with serious reduction in the rate and minute volume of breathing is commonly encountered in barbiturate intoxication. The sensitivity of the center to carbon dioxide is lost, or at best materially diminished, and respiration becomes largely, if not entirely, dependent upon reflex drives for its maintenance (*2*). Increase in the rate of breathing of dogs at this stage may be accomplished by compression of the chest, a maneuver initiating reflex drives involving proprioceptive impulses possibly from both the lung (*4*) and the chest wall (*8*). The application of a constricting band about the mid-thorax as a means of eliciting and maintaining this effect is the subject of this report.

Spirometric recordings, using a Basal Metabolic Rate Unit connected to a tracheal cannula, were made for 11 dogs, each under varying degrees of sodium pentobarbital (Nembutal) narcosis. The dogs were anesthetized with initial intravenous doses of 20–25 mg of the drug/kg of body weight. Subsequent doses of 5–10 mg/kg were given at frequent intervals in order to obtain increasing depths of anesthesia. Constriction of the chest was accomplished by the inflation of a sphygmomanometer cuff encircling the mid-thorax.

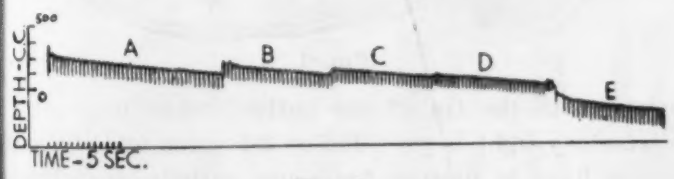

FIG. 1

The stimulating effect of inflation of the cuff upon breathing was immediate at all levels of respiratory depression. During light anesthesia (20–30 mg/kg), inflation of the cuff to various pressures increased respiratory rates slightly and resulted principally in reduction of tidal air volumes (Fig. 1). As toxic levels of the drug were reached (40–60 mg/kg), breathing became abnormally slow (3–5/min). Inflation of the cuff to pressures of 18–24 mm Hg at this point (Fig. 2, arrow) resulted in prompt and significant increases in rates (10–15/min). Tidal air volumes which had increased during the period of abnormally slow breathing were reduced by the constriction to only slightly less than those seen during light anesthesia without constriction, thus assuring adequate tidal gas exchanges (compare Fig. 2, B with Fig. 1, A). The net result was an increase in the minute volume by as much as 115%. Inflation of the cuff to pressures greater than 24 mm Hg reduced tidal air without further increasing the rate. Pressures of as little as 12 mm Hg increased the rate of breathing in some instances. Smaller pressures did not alter respiration. As greater levels of toxicity were reached (60–70 mg/kg), the respiratory minute volume was markedly reduced, principally by a great reduction in the tidal air.

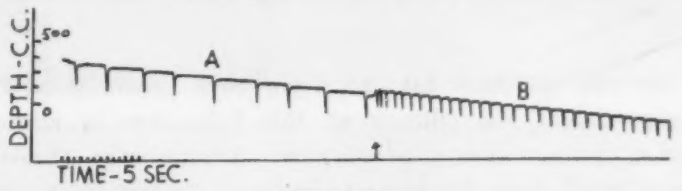

FIG. 2

Constriction of the mid-thorax in this instance resulted in an increase in rate and a slight increase in minute volume, still not sufficient, however, to maintain the animals' oxygen requirements. The respiratory responses to the procedure were maintained in all experiments as long as the cuff was inflated, but promptly disappeared upon deflation.

The effects of constriction, as observed in these experiments, appear to be the result of a Hering-Breuer proprioceptive reflex from the lungs. This is supported by the following observations:

(1) The latent period between the application of the constriction and the response is too short for a chemoceptive reflex (Fig. 2, arrow).

(2) Bilateral vagal section promptly abolishes the effect.

(3) Removal of the common tendinous insertion for the scalenus medius and rectus abdominis muscles does not alter the effect of torso constriction upon respiratory rates or minute volumes in any observable manner. Light digital pressure applied to a circumscribed area of this common tendon (*8*), prior to the latter's removal, initiates a respiratory response. Such responses, however, cease after a few seconds of digital pressure and are followed by a short refractory period.

(4) Nondeforming pressures to the torso and lungs do not give rise to the same type of response as do deforming pressures. The latter apparently deflate the lungs to a greater extent than the former (note elevation of the respiratory base line in Fig. 2, B), thus initiating the excitoinspiratory reflex.

Various chemical, noxious, and proprioceptive reflex mechanisms controlling respiration have long been known (*1, 3, 6*), and methods for their utilization during respiratory center depression have been proposed (*5, 7, 8*). The method as described here is simple, efficient, and nondamaging and is capable of increasing pulmonary ventilation during drug depression. In some experiments animals were able to tolerate the administration of larger doses of the drug (70–75 mg/kg) during the application of the constricting pressure (Fig. 3, first arrow),

but upon deflation of the cuff they lapsed into respiratory failure (Fig. 3, second arrow). Attempts made to revive such animals by reinflation of the constricting cuff (Fig. 3, third arrow) or by artificial respiration were futile. These findings seem to indicate that the torso pressure maintained a volley of vagal nerve impulses to the respiratory center and thus increased the latter's resistance to drug toxicity.

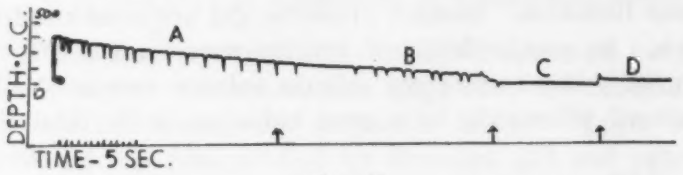

FIG. 3

As yet, sufficient data have not been accumulated for judgment of the efficacy of this maneuver in clinical cases of barbiturate overdosage. Preliminary observations made thus far seem to indicate that it is applicable in such cases.

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A Portable Light for a Dissecting Microscope[1]

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When large numbers of dissections or identifications of insects must be made where no electric current is available, the microscope lamp described below is quite useful. If a microscope must be carried from place to place, the light weight of this lamp is an added advantage.

The whole apparatus is shown in Fig. 1. The source of light (P) is a 'penlight' type lamp (Eveready No. 1152). This is held in a screw-base pilot light socket (H), mounted in the end of a piece of flexible tubing (S) (speedometer cable). The end of the flexible cable remote from the lamp is fastened to a piece of brass, flattened over most of its length to facilitate fastening to the microscope by the screw (A). Mounting in this manner allows the lamp to move up and down with the microscope, thus keeping the light continually on the material being examined. Connection is made with the source of power through a light-weight electric cord using a radio-type midget-tip plug and jack (M). One side of this jack is grounded, as is one side of the socket of the lamp. Thus, only one wire is necessary from the jack to the lamp socket. (The mounting shown is for a Bausch & Lomb microscope. Arrangements for attachment to other makes of microscope will suggest themselves.) Current is supplied by a battery of two standard flashlight cells housed in a plastic case on which is fitted a wire-wound midget voltage control with a resistance of 10 ohms (R). The use of this is necessary, since the lamp which is rated at 2.2 volts is not durable if subjected to the full 3 volts of the battery. The rheostat is mounted on a swinging piece of plastic to facilitate replacing the battery, the shaft of the rheostat making

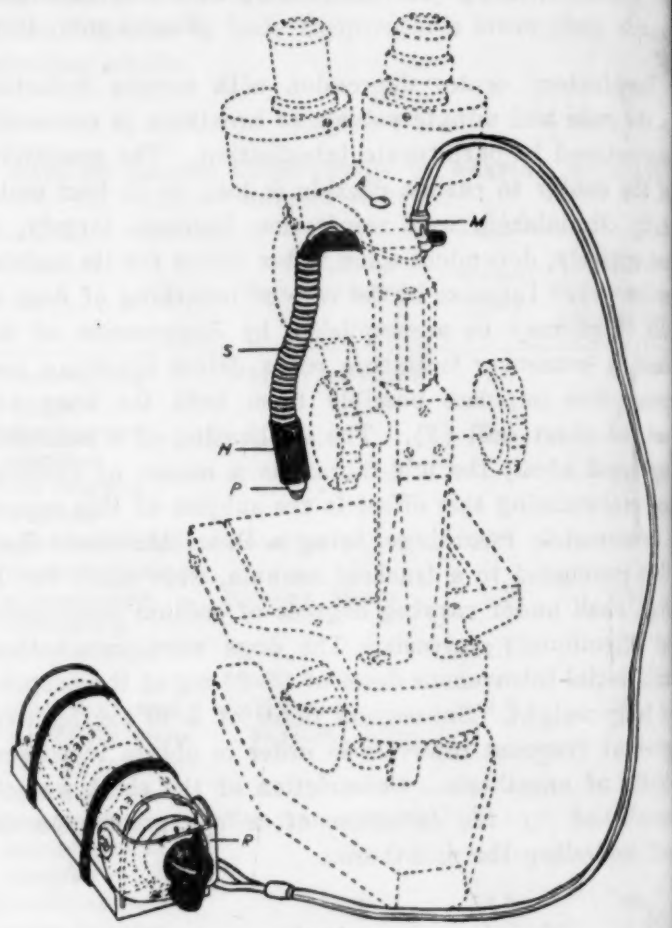

FIG. 1

contact with the tip of the battery when in place. A satisfactory light is provided at 2.2 volts, and if a more intense light is desired for short periods, the rheostat may be adjusted so as to provide the full current of the battery. Satisfactory operation has also been secured from the 6-volt terminals of a transformer, using the proper resistance to reduce the flow of current to the lamp. (Other lamps of higher voltage may be substituted if necessary.)

The chief virtue of the particular lamp used is that a small condensing lens is incorporated in the tip of the lamp itself. The flexible arm is made of such length that the field of the lowest power of the microscope is completely illuminated. The lamp gives off almost no heat.

There is no thought that this apparatus can replace any of the standard microscope lamps. The whole apparatus, including the battery, can be carried in the microscope case, and this complete portability makes it very useful under certain conditions. The total cost of materials is less than $2.00.

[1] Contribution No. 2523, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.